(102)

Applicability of ultrasound in ocular tumors in children and adolescents

Rola badań ultrasonograficznych w nowotworach narządu wzroku u dzieci i młodzieży

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Streszczenie: Purpose: Evaluation of the applicability of ultrasound in children diagnosed for neoplasm of the eye. Evaluation of Doppler ultrasound in visualizing blood vessels within the lesion in eye ball, eye socket and eye lids. Establishing the value of the obtained data concerning the image of vessels and blood flow for the diagnosis, monitoring the course of disease and results of treatment.
Material and methods: The study comprised 80 patients diagnosed and treated for neoplasm of the eye. The study group included 48 girls and 32 boys aged 2 weeks to 18 years. All the patients were subject to full ophthalmologic examination, ultrasound and other imaging techniques. Results: Echogenicity of lesions, focality of growth and the comparison of echostructure did not allow for establishing the degree of malignancy. The presence of vessels in tumor mass and blood flow in tumors were useful for differentiation between malignant and benign tumors.
Conclusions: Ultrasound methods used significantly improve diagnostic possibilities in orbital tumors in children. The obtained pictures of vessels and flow character are typical for some tumors, which together with histopathology of tumors enables establishing of correct diagnosis. CD/PD ultrasound is helpful in monitoring treatment of selected orbital tumors, enables evaluation of biological evolution of capillary hemangioma and assessment of vascularization degree of tumors treated with chemo- and radiotherapy..

Słowa kluczowe: kolorowa ultrasonografia dopplerowska, nowotwory układu wzrokowego, ultrasonografia narządu wzroku, dzieci.
Key words: Color-Doppler imaging, Power-Doppler ultrasound, ocular tumors, ophthalmic echography, children.

Ocular tumors in children and adolescents constitute 0.5% of the total number of tumors. Early recognition of tumors alongside with modern complex therapy constitutes the basis conditioning positive therapy results. It has been difficult, so far, to point out a diagnostic method resulting in high diagnosis efficacy not overburdening the patient, generally accessible and not expensive. Due to the development of medical techniques and the research on biophysical properties of ultrasounds the diagnostic use of ultrasound has been applied in every clinical specialty, including ophthalmology. A and B presentation, as well as Doppler techniques have found practical use in ophthalmologic diagnostics.

The purpose of this paper is to define the applicability of ultrasound in ocular tumors diagnosis in children, as well as in monitoring the development of the disease and the therapy results.

Material and methods

The material comprises the data on 80 patients diagnosed and treated for neoplasm of the eye. There were 48 girls and 32 boys between 2 weeks old and 18 years old in the group examined. All the patients were subject to full ophthalmologic examination further on ultrasound and, in case of need, other imaging techniques. Two ultrasounds methods have been applied: ultrasounds of the time of real presentation B (USG-B) and Colour Doppler ultrasounds (USG-CD, PD). The former method was used as the basic examination at the preliminary stage. Colour Doppler ultrasounds was used at a later stage for the evaluation of the visualization of the lesions. The ultrasounds examinations were performed with the use of Toshiba Sonolayer SSA 270A (Colour Doppler), Acuson 128 XP/10 (Colour Doppler), ATL Ultramark 9 300 HDI (Colour Doppler), ATL Ultramark 9 300 HDI (Colour Doppler). Linear heads with 5-7.5 MHz frequency were used in the examinations. Evalu-

ating the ultrasounds picture in B presentation the following factors were considered: echogenicity and the lay-out of changes, focality of the growth and the comparison of echostructure. The presence and number of vessels in focality area were evaluated in USG-CD examination, as well as the flow character inside vessels. The evaluation of vessels contour was performed with the use of Power Doppler (USG-PD). The flow character was evaluated with the use of spectrum technology (pulsating method – PW). The individual features of the USG-B and USG-CD/PD picture were independently analysed. Other imaging diagnosis examinations, namely: Roentgen angiography (RA), spiral computer tomography (SCT) and magnetic resonance tomography (MRT) were additionally performed in case of some patients for diagnosis and observation of tumour changes in non operational treatment.

In order to define, to what extend the features of ultrasounds pictures are characteristic of individual groups of neoplasm and whether basing on them, one can differentiate their degree of malignancy, they were analysed in the Mann-Whitney-Wilcoxon test.

The results and discussion

The analysis of the obtained empirical data was performed dividing the neoplasm into 3 groups: malignant tumors (melanomas, retinoblastomas, rhabdomyosarcomas and gliomas), locally malignant tumors (capillary hemangiomas, cavernous hemangiomas and meningiomas) and benign tumours (charistomata type tumors and inflammable tumors) (tab. I).

In the group of 7 children with retinoblastoma all the tumors were hyperechogenic, with irregular contours and remarkably heterogeneous echostructure (in the tumor mass there appeared numerous scattered small calcifications with a succeeding shadow). One could clearly see vessels in tumor mass in USG-CD/PD picture. In most cases the vessels were crooked. The flow noted in spectral technique showed resistance nearing the one in central retinal artery or was of low resistance (fig. 1).

A 14 year old girl with uveal melanoma was observed. In B presentation the tumour was visible as a focal change with low echogenicity, copular (lenticular) in shape with the presence of a typical vascular cavity – „choroidal excavation". The tumor contour was regular, its echogenicity homogeneous in all examinations. Doppler examination showed singular vessels within the tumor. Vessels contour was regular and the flow nearing that in central retinal artery (fig. 2).

There were two children with eyelid and eye socket rhabdomyosarcoma in the examined group. One tumor was hypoechogenic the other with the echogenicity nearing eye socket tissue. The changes appeared unifocally. The contour of one tumour was regular the other partly irregular. The echostructure of both changes was homogeneous. The vessels inside the tumor mass were observed in USG-CD/PD examination. The vessels were regular. The flow noted in spectral technique was intensive low resistant (fig. 3).

In case of two children eye socket tumor of glioma type was diagnosed. One of them was hipoechogenic the other with echogenicity similar to eye socket tissue. The changes appeared unifocally. The tumors contours were partly irregular. The echostructure of one change was homogeneous of the other partly heterogeneous. Vessels in tumor mass were observed in USG-CD/PD examination. They were regular in one change, irregular in the other. The

Diagnosis	Girls	Boys	Min. years	Max. years	Med. years
Retinoblastoma	2	5	4/12	4	1.8
Melanoma	1	0	14	14	14
Rhabdomyosarcoma	1	1	9	11	10
Glioma	2	0	7	13	10
Meningioma	2	0	4	18	12
Capillary hemangioma	27	20	1/12	16	2.2
Cavernous hemangioma	1	1	13	13	13
Choristoma	8	2	2/12	13	4.3
Inflammable tumor	4	3	2	18	10.7
Total	48	32			

Tab. I. Quantitative distribution of diagnosed ocular tumors taking into account patients' sex and age.

Tab. I. Liczba rozpoznanych guzów narządu wzroku z uwzględnieniem płci i wieku chorych.

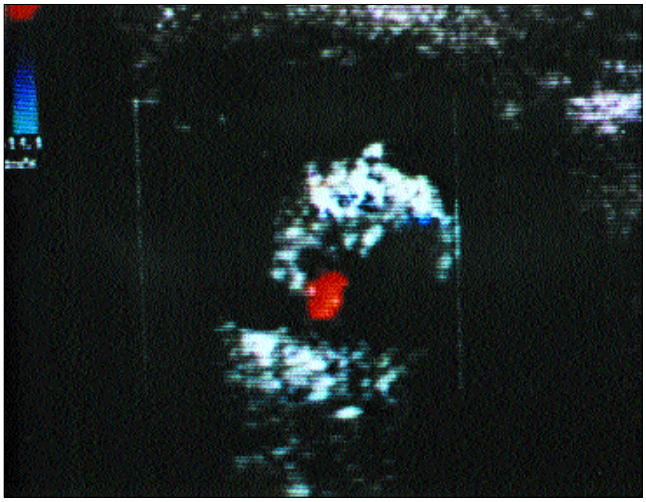

Fig. 1. USG-CD picture of the retinoblastoma. In the tumor small vessels visible.

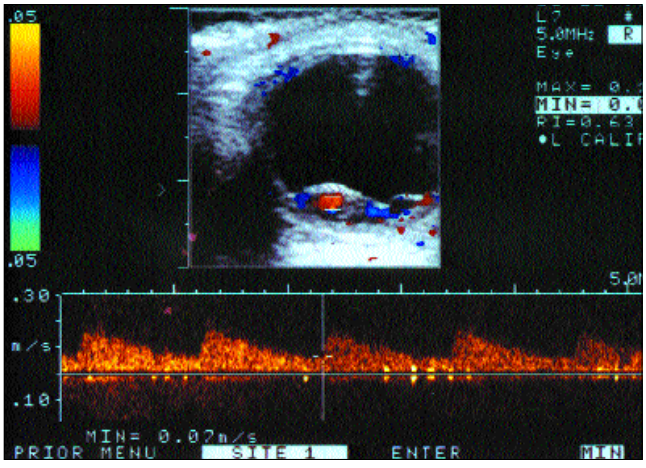

Fig. 2. USG-CD picture of uveal melanoma. Spectrum flow recording showing low resistance flow.

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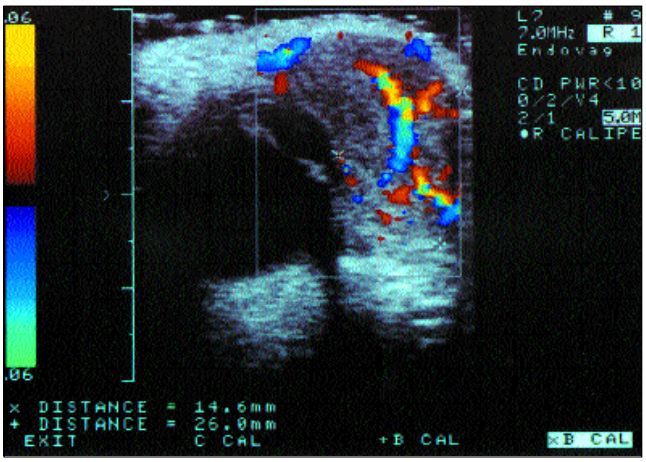

Fig. 3. USG-CD picture of orbital rhabdomyosarcoma. Numerous smoothly shaped vessels visible in tumor structure.

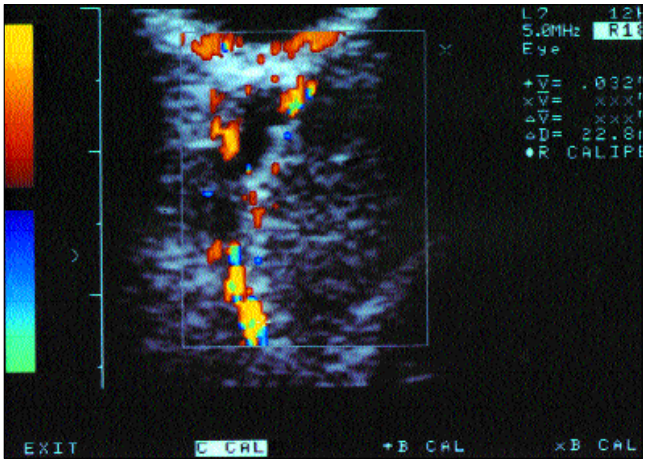

Fig. 6. USG-CD picture of cavernous hemangioma. Hypoechogenic tumor with heterogeneous echostructure and irregular contour.

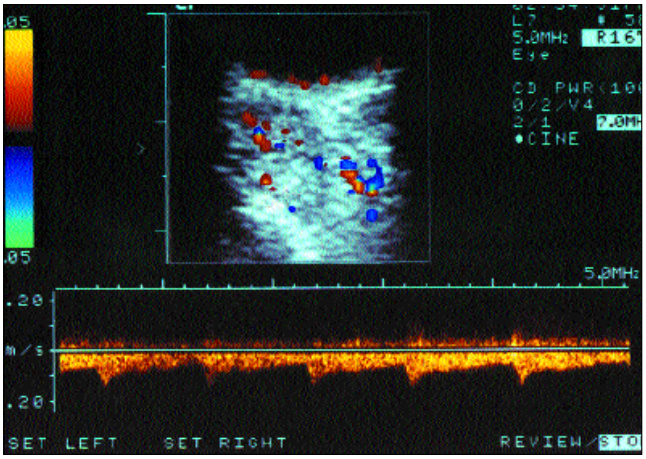

Fig. 4. USG-CD picture of orbital glioma. Spectrum examination used points to the flow with resistance similar to the values obtained in central retinal artery.

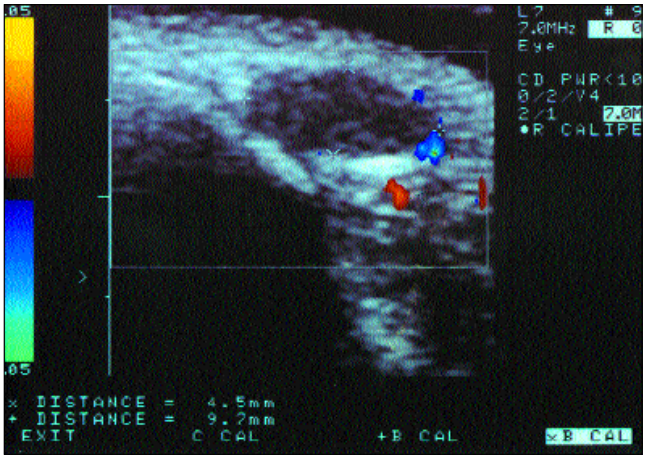

Fig. 7. USG-CD picture of choristoma. Hypoechogenic tumor with homogenous structure and regular contour. No vessels in tumor mass.

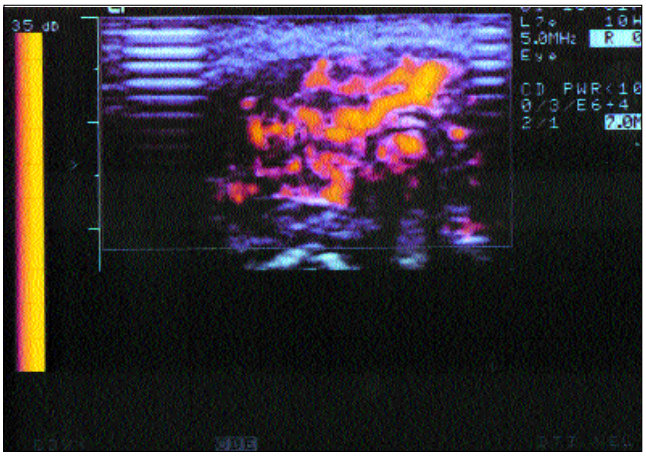

Fig. 5. USG-PD picture of the capillary hemangioma in the phase of proliferation.

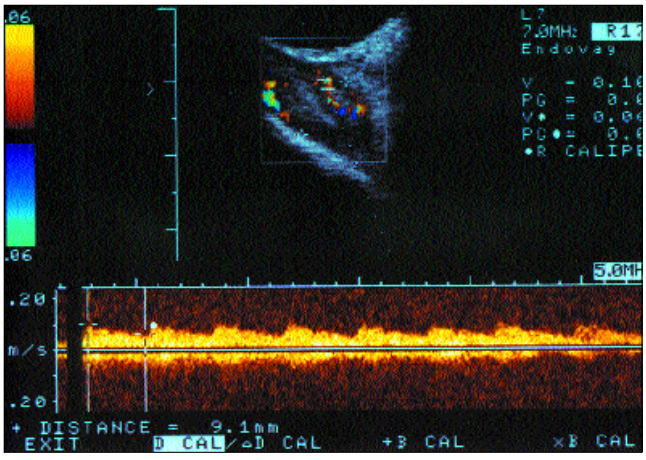

Fig. 8. USG-CD picture of eye socket inflammatory tumor. Hypoechogenic tumor with heterogeneous echostructure, small vessels in tumor mass with irregular contours.

flow noted in spectral technique was intensive, highly resistant and isoresistant (fig. 4).

47 patients with capillary hemangioma of eyelids and eye sockets were diagnosed. The hemangioma were seen in USG B presentation examination as poorly separated areas with different echogenicity and echostructure. The tumors are hypoechogenic and isogenic to eye socket tissue in the early phase of proliferation, in the phase of regression they are hyperechogenic and heterogeneous in structure (fig. 5).

Two patients with cavernous hemangiomas were observed. Both the tumors were hypoechogenic and appeared unifocally. Their contours were irregular. The echostructure in both changes was heterogeneous. Separate vessels were observed. They were regular. The flow noted in spectral technique was highly resistant (fig. 6).

Two children were examined with meningioma situated within optic nerve. Both tumors were hypoechogenic and unifocal. The contour of one was regular, the other, partly irregular. The echostructure of both changes was homogeneous. Individual vessels placed peripherally in one of the changes were observed in USG-CD/PD examination. They were regular. The flow noted in spectral technique was highly resistant.

Congenital anomalies – choristoma: there were 10 patients in this group with the diagnosis of choristoma type of tumor. The tumors were hyper, hypo and isogenic appearing unifocally. The tumor contours were usually regular, in 3 cases partly irregular. The echostructure of the changes was usually homogeneous, in two cases, partly heterogeneous. In USG-CD/PD examination vessels in tumor mass were not observed (fig. 7).

7 patients were diagnosed with inflammatory infiltration of eyelids and eye sockets. The inflammatory tumors showed various echogenicity depending on the development of inflammation process. The changes appeared unifocally with irregular tumour contours and heterogeneous echostructure. One could trace the presence of delicate peripheral vessels in inflammatory tumors at the early stages of inflammation, not visible at the later stage (fig. 8).

It was decided, basing on the performed statistical analysis, that the echogenicity of the examined tumor does not make it possible to define the degree of malignancy of the tumor. The significance level measured comparing groups in all cases stands at more than 0.3. Growth focality did not make it possible to distinguish between benign and locally malignant tumors or between benign and malignant ones. The comparison between the group of malignant tumors and locally malignant ones made it possible to reveal the statistically important difference ($p < 0.001$). The number of people within the groups with simultaneous sporadic of multifocal growths influenced the results obtained. The tumour contour or the comparison of echostructure homogenity, as well as, echogenicity did not influence the credible definition of tumour malignancy. The flow in tumor vessels makes it easier to differentiate between the group of benign tumors and locally malignant ones ($p < 0.001$), and also between the group of benign and malignant tumors ($p = 0.0014$). No statistically important difference was shown between malignant and locally malignant tumors ($p > 0.5$).

Discussion

The problem of tumor malignancy is very complex. From histopathological point of view tumor malignancy depends on the differentiation of its cells and proliferation possibilities. Apart from the histopathological type, the location of the change, the manner of its growth and the interrelation between the tumor and the organism are of utmost importance. The presence of vessels in tumor mass is another essential factor deciding about its malignancy since well vescularized and blood supplied tumors have bigger chances of proliferation and spreading.

As it appeared from the presented examinations, it is not easy to correlate the degree of tumor echogenicity with the degree of its malignance. It is very difficult to work out the objective frame of reference pattern, since eye socket tissue similarly to vitreous body may undergo pathological processes changing their sonographic picture. Many authors underline the role of echogenicity evaluation in diagnosis. Avitabile and others (1) give that method as essential in differentiating retinoblastomas from hemangioma tumors. Goes and others (2) stress the importance of the method in the evaluation of choroid melanomas, Hasenfratz (3) in diagnosis of eye socket tumors. Basing on the material presented in the paper one cannot accept that echogenicity is a univocal evaluation criterion pointing to tumor malignancy and that that feature should be considered in the USG picture features complex.

Multifocality was sporadically observed in the examined material only in cases of retinoblastoma and hemangioma. In the presented paper it is difficult to correlate multifocality with the degree of tumor malignancy, mainly just due to the incidentally of the phenomenon. Other authors (4) quote similar observations.

It is difficult to univocally link tumor contour similarly to echogenicity with the degree of malignance. According to Hasenfratz (3) tumor infiltrational growth making it impossible to visualize the border line between the tumor and eye socket fat suggests diagnosing malignancy of growth process. According to our observations capillary hemangioma constitute considerable obstacle in the mentioned relations because of not showing clear contours, either. Basing on the above, one could state that tumor contour is not a univocal evaluation criterion pointing to the degree of malignancy.

As the data included in the presentation suggest, it is not easy to link tumor inner echostructure with the degree of malignancy. Numerous authors, among others Goes and others (2), Avitabile and others (1) state that homogeneous echostructure is characteristic of melanomas as opposed to heterogeneous structure of retinoblastomas. Capillary hemangiomas, varied sonographic picture of which blurs statistical data, constitute a certain difficulty in the mentioned own observations.

Gutthof (5), Falco and others (6), Wollf-Korman and others (7) presented the importance of USG-CD in visualizing the vascular of ocular tumors. All of them unanimously underline the diagnostic benefits of that method, mainly in relation to choroidal melanoma. Vessels imagines in Doppler examination turn out to be helpful in the evaluation of tumor character. The image of capillary hemangioma is the most spectacular one. Retinoblastomas and melanomas vascularization is also very evident in Doppler options. In turn, with tumors showing considerable diversification, the vascularization is meagre, with vessels placed peripherally, in most cases. Vessels contours traced in Doppler examination can also be helpful in tumor character evaluation. Here again, the picture of capillary hemangioma seems most convincing, showing crooked vessels and irregular contours. The vessels within retinoblastomas, melanomas and rhabdomyosarcomas are also very clear; however their appearance is more regular. In benign tumors the vessels are narrow; one can

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often trace their modeling peripherally in the lesions (2,7). The evaluation of the flow character in spectral technique makes it possible to foresee the degree of metabolism of the tissue nourished by the vessel observed which is helpful in tumor character evaluation. The comparison of the measurements within tumor mass with the flow measurements in central retinal artery allowed obtaining relative results objectivization. The picture of capillary hamangioma is most convincing here again, showing in the proliferation phase a very low flow resistance. The flow within retinoblastomas, rhabdomyosarcomas and melanomas also shows lower resistance in comparison with that in central retinal artery. In case of tumors with a big degree of differentiation the flow is of high resistance character. Highly malignant tumors and capillary hemangiomas may be characterized with ample vascularization. The remaining tumors turned out to be poorly vascularized. The above observations are consistent with the data from literature quoted by Falco and others (6), Jajn and others (4), Stefańczyk and others (8,9,10,11,12), Muller-Forell and others (13), Scott and others (14), Vazquez and others (15), Wolff-Korman and others (7).

It is evident from the above presented analysis of own material data, as well as from other authors' opinions that in ophthalmologic pediatric diagnosis supporting the clinical evaluation with ultrasound methods in the first place is desirable as limiting the need of radiological examinations, eliminating ionizing radiation and contrasting means.

Conclusions

1. Ultrasound methods used significantly improve diagnostic possibilities in orbital tumors in children and adolescents.
2. Color-Doppler and Power-Doppler ultrasounds allow for visualization of blood vessels within tumors. The obtained pictures of vessels and flow character are typical for some tumors examined, which, together with vessels imaging reflecting tumors histopathology, enables establishing of correct diagnosis.

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