Eye socket vessels hemodynamics via Duplex Sonography in case of malignancies.

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Purpose

Surveying the hemodynamics of eye socket vessels in case of malignancies and determining the indications to the treatment type (surgery, radio- or chemotherapy)
Methods and Materials

from 2004 to 2012 in this present study 52 patients (M/F=31/21, m.a. 46±4,8) with malignancies of the eye socket and 25 (M/F= 14/11, m.a. 44±6,3) patients with no signs of eyes' pathology have been enrolled in comparison.
The eye socket tumors were diagnosed and confirmed by the full examination of the ophthalmologist.
Data were correlated with MRI, angiography and surgical findings (95 % confidence interval for R2 is 0.962 to 0.988)
Patients were examined via Sequoia 512 (Acuson), GE Logic 7 and Vivid 7 (B-mode and Duplex regimen)
Study comprised stages:
1) B-mode
- localization, form, size, structure, shape of the tumor
- reposition and kinematic probe (specially developed technique, aimed to determine the tumor displacement concerning the surrounding tissues for differentiation of the tumors grow type as invasive or non-invasive. Patent # RU 2231297 C1)
- thickness and echo structure of the eye layers (no differentiation of the layers), optic nerve and extraocular muscles
- the rectilinear direction of optic nerve in retrobulbar space
- the echo parameters assessment of vitreous humor, soft tissues of superior and inferior eyelid, retrobulbar space in case to determinate the pathology.
2) the vessels of the eye socket hemodynamic study (Color Flow Mapping and Pulsed Wave Doppler), standard parameters are assessed:
- a.ophthalmica
- a.retinae centralis,
- aa. ciliaris posterior brevis and longus
- v.ophthalmica superior , v.retinae centralis
- intratumoral blood flow
The Duplex mode examinations were performed twice: as the diagnostic step for the malignancy determination and as the post-treatment follow-up, aimed to control the relapse.
Results

Doppler data in group of patients with no eye pathology A. retinae centralis  
Vmax=0,12±0,023 m/sec , a. ophtalmica 0,32±0,16 m/sec,a. ciliaris posterior longus  
0,19±0,08 m/sec and a. ciliaris posterior brevis 0,16±0,04 m/sec, v. retinae centralis  
0,04±0,02 m/sec, v. opthalmica superior 0,08±0,01 m/sec. A. ophtalmica RI = 0,70±0,02,  
a. retinae centralis RI= 0,67±0,01.

In case of intraocular or retrobulbar space malignancies a. ophtalmica blood velocity  
from 30% to 68 % increased. The eye socket vessels hemodynamic indices depending  
on the localization of the malignancy are shown at the tables 1, 2.

Table 1. The average Doppler indices of eye socket vessels hemodynamic of the patients  
with intraocular malignancies (n=21) compared with control group.

<table>
<thead>
<tr>
<th>Vessels</th>
<th>The average Doppler indices of hemodynamic</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vmax, cm\sec</td>
<td>Vmin, #m\sec</td>
<td>RI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. ophtalmica</td>
<td>45,1± 13,7</td>
<td>9,5 ± 6,3</td>
<td>0,77 ± 0,06*</td>
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<tr>
<td></td>
<td>(32,0 ± 8,2)</td>
<td>(12,6 ± 4,8)</td>
<td>(0,70 ± 0,02)</td>
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</tr>
<tr>
<td>A. retinae centralis</td>
<td>15,8 ± 3,1*</td>
<td>2,8 ± 0,5*</td>
<td>0,77 ± 0,07*</td>
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<tr>
<td></td>
<td>(12,0 ± 2,3)</td>
<td>(4,3 ± 0,2)</td>
<td>(0,67 ± 0,01)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A. ciliaris posterior</td>
<td>17,8 ± 6,3</td>
<td>6,8 ± 2,9</td>
<td>0,61 ± 0,02</td>
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<td></td>
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</tr>
<tr>
<td>brevis medialis</td>
<td>(16,0 ± 4,1)</td>
<td>(5,5 ± 3,2)</td>
<td>(0,64 ± 0,03)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A. ciliaris posterior</td>
<td>18,7 ± 5,4*</td>
<td>7,5 ± 2,1*</td>
<td>0,60 ± 0,01*</td>
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<td></td>
</tr>
<tr>
<td>brevis lateralis</td>
<td>(15,9 ± 4,0)</td>
<td>(5,58 ± 3,1)</td>
<td>(0,64 ± 0,03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. ciliaris posterior</td>
<td>20,2 ± 6,2</td>
<td>6,8 ± 2,7</td>
<td>0,66 ± 0,02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>longus medialis</td>
<td>(19,2 ± 8,0)</td>
<td>(6,0 ± 2,9)</td>
<td>(0,68 ± 0,03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. ciliaris posterior</td>
<td>21,9 ± 4,8</td>
<td>6,2 ± 3,2</td>
<td>0,71 ± 0,02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>longus lateralis</td>
<td>(19,0 ± 8,3)</td>
<td>(5,9 ± 3,0)</td>
<td>(0,69 ± 0,02)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>v. retinae centralis</td>
<td>6,2 ± 4,5</td>
<td></td>
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<td></td>
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<tr>
<td>v. opthalmica superior</td>
<td>17,3 ± 3,4</td>
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</tbody>
</table>
The control group indices are in parenthesis.

* the parameters are significantly different compared to the control group (p<0.05)

As follows from the table 1 in case of intraocular tumors the Vmax of a.retinae centralis and a. ciliaris posterior brevis is significantly increased, whereas Vmin and RI are decreased. This indicates the augmentation of the blood flow within the tumor which corresponds to the angiogenesis theory. We determined the blood flow changes of a. ciliaris post.long. lateralis associated with no blood flow changes of a. ciliaris post.long. medialis. This is associated with the tumor primary localization (lateral edge of the eyeball 76.9%). The intraocular tumors were represented by the choroidal melanomas in 19 cases, vitreous humor melanoma - 1, basal cell carcinoma of the eye - 1.

Table 2. The average Doppler indices of eye socket vessels hemodynamic of the patients with malignancies localized in retrobulbar space (n=28) compared with control group.

<table>
<thead>
<tr>
<th>Vessels</th>
<th>The average Doppler indices of hemodynamic</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Vmax, #m/sec</td>
<td>Vmin, #m/sec</td>
<td>RI</td>
</tr>
<tr>
<td>a.ophtalmica</td>
<td>54.1 ± 13.7*</td>
<td>19.2 ± 6.3*</td>
<td>0.65 ± 0.04*</td>
</tr>
<tr>
<td></td>
<td>(32.0 ± 8.2)</td>
<td>(12.6 ± 4.8)</td>
<td>(0.70 ± 0.02)</td>
</tr>
<tr>
<td>A. retinae centralis</td>
<td>16.8 ± 4.1*</td>
<td>6.5 ± 1.5*</td>
<td>0.61 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>(12.0 ± 2.3)</td>
<td>(4.3 ± 0.2)</td>
<td>(0.67 ± 0.01)</td>
</tr>
<tr>
<td>A. ciliaris posterior brevis medialis</td>
<td>19.4 ± 6.3*</td>
<td>9.1 ± 4.5</td>
<td>0.53 ± 0.02*</td>
</tr>
<tr>
<td></td>
<td>(16.0 ± 4.1)</td>
<td>(5.5 ± 3.2)</td>
<td>(0.64 ± 0.03)</td>
</tr>
<tr>
<td>A. ciliaris posterior brevis lateralis</td>
<td>18.9 ± 4.7*</td>
<td>8.7 ± 3.7</td>
<td>0.54 ± 0.01</td>
</tr>
<tr>
<td></td>
<td>(15.9 ± 4.0)</td>
<td>(5.58 ± 3.1)</td>
<td>(0.64 ± 0.03)</td>
</tr>
<tr>
<td>A. ciliaris posterior longus medialis</td>
<td>21.2 ± 5.0</td>
<td>7.8 ± 2.7</td>
<td>0.62 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>(19.2 ± 8.0)</td>
<td>(6.0 ± 2.9)</td>
<td>(0.68 ± 0.03)</td>
</tr>
<tr>
<td>A. ciliaris posterior longus lateralis</td>
<td>22.0 ± 3.9</td>
<td>8.6 ± 3.8</td>
<td>0.61 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>(19.0 ± 8.3)</td>
<td>(5.9 ± 3.0)</td>
<td>(0.69 ± 0.02)</td>
</tr>
<tr>
<td>v.retinae centralis</td>
<td>8.2 ± 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.0 ± 0.02)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The control group indices are in parenthesis.

* the parameters are significantly different compared to the control group (p<0.05)

As follows from the table 2, RI of all the vessels decreases unevenly: 18% for aa. ciliaris post.brevis medialis and lateralis and less than 10% for the rest of vessels. Moreover the analysis of differences distribution showed that IR didn't changed significantly in the half of the cases.

We determined the significantly different indices (p<0,05) of a.optalmica, a.retinae centralis, aa. ciliaris post.brevis. The neoplasms of retrobulbar space were represented by the hemangiomas in 2 cases, AV malformation - 1, malignancies of lachrymal gland - 7, basal cell carcinoma - 3, meningioma-6, pseudotumor - 3, posttraumatic hematoma - 2, metastases - 4.

The size of the intraocular tumors in our study is 9,75±5,5 mm, prominence-6,0±3,5 mm; neoplasms of the retrobulbar space 19,1±8,3 mm . We noticed that the changes of blood flow velocity of a.retinae centralis and a.ophtalmica are insignificant if the tumor size is relatively small. According to stated above we classified the patients on the groups: 1st - with tumor size from 1 to 9 mm, 2nd - from 10 to 20 mm, 3rd - over 20 mm. We analyzed the average parameters of velocity and resistance index (Vmax, Vmin, RI) in each group. This data were assessed using the cluster analysis Ward's method (Blashfield, R. K., & Oldenderfer, M. S., 1989). It allowed to determinate the significant intergroup variation of the a.retinae centralis, a.ophtalmica and aa. ciliaris post.brevis medialis and lateralis indices ( the IR dramatic decrease and the blood flow velocity increase)

Considering the usage of the accurate measurement data, we employed the t-criterion for the correlated (pairwise adjoin) sampling (Rebrova, 2002) for the purpose of comparison. The most significant changes (correlation) were the Vmax increase and RI increase of the a.retinae centralis, a.ophtalmica and aa. ciliaris post.brevis.

Thereby the correlation between the blood flow velocity and tumor size is established. The steal syndrome is discovered in 3 cases (5,8%) and associated with dramatic decrease of a.ophtalmica blood flow velocity (less than 0,2 m/sec) with the collateral type of it, higher (compared to a.ophtalmica) velocities for aa.ciliaris and intratumoral blood flow. (Pic.4)
The optic nerve ischemia is discovered in 7 cases (13, 5%) by non ultrasonic method. The blood flow changes of the aa. ciliaris post.brevis and longus were noticed, but the follow up and another statistic analysis is required for the conclusions in this case.

The intratumoral blood flow (from minimal to strongly marked indices) is determined in 46 cases. In case of uveal melanoma the average blood flow velocity is 0,121±0,082 m/sec, in case of retrobulbar space tumors -0,0 82 + 0,024 m/sec. Up to 4 vessels are visualized. The arterial low resistant blood flow is registered in 57,1%, arterial high resistant blood flow - 14,3%, collateral blood flow - 28,6%. The average RI is 0,62±0,1. The venous blood flow is indicated only in 2 cases (4,3%). Thereby the arterial blood flow is typical for the uveal melanomas. Analyzing the intratumoral blood flow of the retrobulbar space malignancies we determined the various types of the blood flow. The intratumoral blood flow was not registered at all in case of meningioma (6 patients). The hemodynamics of the a.retinae centralis, a.ophtalmica is changed.

The vena ophthalmica superior outflow was decreased in case of big size of retrobulbar malignancies and its localization on the top of eye socket.
Fig. 1: Two patients with the intraocular malignancies Duplex scan (B-mode and Color Flow Mapping). Intratumoral blood flow in CFM mode. The four color loci on the left image, and the vessel on the periphery on the right image.

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Fig. 2: 70-year-old patient, a.ophtalmica blood flow velocity (Vmax=0.66m/sec, RI=0.70).

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Fig. 3: 62-year-old patient, basal cell carcinoma of eyelid external margin (B-mode, CFM + PW). Upper left corner: the tumor in B-mode (between +...+); upper right corner
and lower left corner: intratumoral blood flow; lower right corner: a. ciliaris post.breviss increased blood flow.

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**Fig. 4:** Steal syndrome of the patient with AV-malformation. On the left image - a.ophtalmica blood flow decrease. On the right image - blood flow amplification of the feeding vessel.

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Conclusion

1. The eye socket vessels Doppler mode analysis in case of malignancies indicates the increasing a.ophthalmica and a.retinae centralis Vmax. The Doppler data is correlated with tumor size and localization.
2. The a.ophthalmica and a.retinae centralis steal syndrome and optic nerve ischemia sings were determined in 5,8 % and 13,5 % of the cases.
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