Ocular outcomes in 4-year old prematurely born children

Ocena narządu wzroku u dzieci w wieku 4 lat urodzonych przedwczesnie

Purpose: The aim of the study was to assess functional and structural ophthalmologic outcomes in 4-year old very low birth weight children (VLBW).

Material and Methods: A group of 82 VLBW children including: (1) children without retinopathy of prematurity – group 0 (n = 30), (2) children with retinopathy of prematurity with no indications for laser coagulation – group 1 (n = 20), (3) children with retinopathy of prematurity treated with laser coagulation – group 2 (n = 32) were enrolled. Functional (visual acuity, visual evoked potentials, stereopsis, color vision test) and structural (anterior eye segment examination and fundoscopy) outcome, cycloplegic refraction, intraocular pressure and angle of squint were examined in all children. Developmental Test of Visual Perception was also assessed.

Results: Very good visual acuity was presented in 56 (68.3%) patients, good visual acuity in 11 (13.4%) children, visual acuity between 0.4 and 0.2 in 13 (15.9%) and unfavorable function (equal or less than 0.1) was observed in 2 (2.4%) children. Twenty-three patients (28.1%) were myopic, 57 patients (69.5%) were hyperopic. Astigmatism > 1D occurred in 49 (59.8%) patients. Anisometropia larger than 2 D occurred in 7 patients (8.7%). There was no statistical difference between frequency of mentioned above complications between the groups. Abnormal VEP results were more common (14 children -54%) in group 2 as compared to other groups (group 0 - 7 children -25%, group 1 – 4 children -24%; p = 0.044). Moreover, the lower percentage of group 2 children presented stereopsis vision (46.9%, group 0 – 93.3%, group 1 – 90%; p<0.05). Children with retinopathy of prematurity treated with laser coagulation had significantly lower Developmental Test of Visual Perceptions scores. In group 1, in 1 child naevox pigmentosus of the eyelid was observed, in group 2 in one child eyeball atrophy in the right eye and aphakia in the left eye were diagnosed. In 1 child in group 0 optic disc drusen were observed, in 2 children optic discs were pale. In 2 children in group 2

 Cel: Celem pracy była ocena funkcjonalna i strukturalna narządu wzroku u dzieci w wieku 4 lat z bardzo niską masą urodzeniową.

Materiał i Metodyka: Do badania włączono 82 dzieci z bardzo niską masą urodzeniową: (1) dzieci bez retinopatii wcześniaków grupa 0 (n=30), (2) dzieci z retinopatią wcześniaków bez wskazań do laserokoagulacji siatkówki grupa 1 (n=20), (3) dzieci z retinopatią wcześniaków leczone laserokoagulacją grupa 2 (n=32). U wszystkich dzieci przeprowadzono ocenę funkcjonalną narządu wzroku (ostrość wzroku, wywołane potencjały wzrokowe, stereopsja, badanie widzenia barw), ocenę strukturnalną narządu wzroku (badanie przedniego odcinka, badanie dna oka), badanie refrakcji po porażeniu akomodacji, pomiar ciśnienia wewnątrzgałkowego oraz badanie kąta zeza. Wykonano również test rozwoju percepcji wzrokowej.

Wyniki: Bardzo dobra ostrość wzroku występowała u 56 (68,3%) pacjentów, dobra ostrość wzroku u 11 (13,45%), ostrość wzroku pomiędzy 0,4 a 0,2 u 13 (15,9%), a niekorzystna funkcjonalnie ostrość wzroku (mniej niż 0,1) występowała u 2 (2,4%) dzieci. Dwadzieścia sześciu dzieci (28,1%) miało krótkowzroczność, 57 dzieci (69,5%) miało nadwzroczność. Astigmazm > 1D występuł u 49 (59,8%) dzieci. Różnokrotność większa niż 2 D występowała u 7 pacjentów (8,7%). Nie było różnic statystycznie znamiennej pomiędzy częstościami występowania wyżej wymienionych zaburzeń w poszczególnych grupach. Nieprawidłowy wynik badania wywołanych potencjałów wzrokowych był najczęstszym (14 dzieci -54%) w grupie 2 porównanej z pozostałymi grupami (grupa 0 - 7 dzieci -25%, grupa 1 -4 dzieci -24%; p=0.044). Ponadto, w grupie 2 najmniejszy odsetek dzieci prezentowało przestrzenne widzenie (46,9%), grupa 0-93,3%, grupa 1-90%; p<0.05). Dzieci z retinopatią wcześniaków leczone laserokoagulacją siatkówki miały statystycznie znamienne niższy wynik testu rozwoju percepcji wzrokowej. W grupie pierwszej, u jednego dziecka...
Introduction

With the advent of new technologies and improved care for premature newborns, survival rates of extremely low birth weight (ELBW) neonates have changed from 5 to 65% and those of very low birth weight (VLBW) infants from 35% to 90% during the recent years [1]. Therefore, retinopathy of prematurity (ROP) is being increasingly diagnosed in these infants. Although, with proper care, most neonates develop a mild degree of ROP, in some babies the condition is progressive and needs treatment [2]. Children with ROP are at an increased risk of visual impairments, including acuity deficits [3], strabismus [4], reduced contrast and color sensitivity [5], refractive errors [3] and visual field deficits (VFDS) [6]. However, the extent to which these ophthalmic morbidity is attributable to ROP per se has not been clearly shown. Visual sensory and perceptual skills are important for a range of functions and everyday activities, such as classroom learning, overall school performance [7-10], successful social interaction, and social cognition [11-13]. Consequently, understanding the nature and frequency of visual deficits in extremely preterm children is vital with regard to informing adequate and appropriately targeted clinical follow-up and increasing focus on developing avenues for remediation. The aim of the study was to compare functional and structural outcomes in 4-year old premature born children divided in 3 groups: children without retinopathy of prematurity, children with retinopathy of prematurity with no indications for laser coagulation and children with retinopathy of prematurity treated with laser coagulation.

The Ethical Committee for Clinical Investigations of Collegium Medicum, Jagiellonian University, approved the study.

Material

A prospective study was conducted in the Department of Ophthalmology and Ocular Oncology, Jagiellonian University, Cracow, Poland between January 1, 2013 and May 31, 2015. From 1 October 2008 to 31 October 2010 one hundred and four newborns (gestational age < 32 weeks, birth weight<1500 grams) were discharged from the Neonatal Intensive Care Unit (NICU) of the Polish-American Children’s Hospital, Cracow, Poland. All of those alive who responded to the invitation was divided into 3 subgroups based on the anamnesis: (1) children without retinopathy of prematurity – group O (n = 30), (2) children with retinopathy of prematurity with no indications for laser coagulation – group 1 (n = 20), (3) children with retinopathy of prematurity treated with laser coagulation – group 2 (n = 32). The neonatal data used for the study were recorded during NICU’s stay daily in a prospective manner and stored in computer databases.

Methods

Visual acuity

In order to measure monocular distance visual acuity (DVA), we used a Snellen chart available for young children with optotypes in the form of simple pictures. The chart was placed at a distance of 5 meters and the result was given as a fraction in accordance with the Snellen rule. If we were not able to perform the examination in uncooperative patients, a preferential looking test (PL) was used. This was due to the fact that infants or children prefer to look at a pattern rather than a homogeneous stimulus. This test consists of sixteen 50 cm x 25 cm rectangular cards. Each card features a 12.7 cm square with black and white stripes located on the left or right side 8 cm away from the center of the card (Teller Acuity Cards). The width of the stripes is different on each card. Various spatial frequency is expressed in cycles per centimeter and ranges from 0.32 to 38 cy/cm (assessment of resolution, not recognition of visual acuity). Children are exposed to a stimulus in the form of a stripe (starting from the widest to the narrowest) and the examiner observes the eyes for fixation movements without knowing the stimulus position. Low frequency stripes are seen more easily than high frequency ones. The cy/cm scale is converted to the tachistoscope value according to the corresponding formula [14,15]. We identified five ranges depending on the tested visual acuity: 1st - DVA < 0.1, 2nd - DVA = 0.2-0.4, 3rd - DVA = 0.5-0.7, 4th - DVA = 0.8-1.0.

Refraction

A grade of vision abnormality was determined in each child with the aid of an automatic keratorefRACTometer (UNICOS, URK-800) after cyclography (40 minutes after triple instillation of 1% Tropicamide). If the examination with the keratorefraction meter was not feasible, retinoscopy was performed. Based on the refractive errors, 8 groups were selected: anisometropia ≤2D, anisometropia >2D, myopia >7D, myopia <3D, myopia 3-7D, hyperopia >7D, myopia <3D, myopia 3-7D, not examined.

Visual evoked potentials

Visual evoked potentials (VEP) are primarily used to measure the functional integrity of the visual pathways from the retina via the optic nerve to the visual cortex of the brain (Brodman areas 17,18,19). They refer to electrical potentials initiated by brief visual stimuli: a black and white checkerboard (pattern VEP; PVEP) or a flash of light (flash VEP; FVEP) which are recorded from the scalp overlying the visual cortex. The time from the activation of the stimulus on the retina to the culmination of a positive wave (P100 wave) and the amplitude of this wave are analyzed. Other positive and negative waves in the record are not analyzed because of their high variability. VEPs are a type of electroencephalography; they are refined from unwanted noise and averaged in a computer system. The test is performed in accordance with the current standard established by ISCEV (International Society for Clinical Electrophysiology of Vision) [16].

The electrophysiological examination in this study was carried out using the TOMEY EP-1000 device. The patients had 3 electrodes attached according to the international system 10/20: an active electrode in the occipital area, a reference electrode about 11 centimeters away from the nasopharynx and a grounding electrode on the midline, and a grounding electrode on the earlobe. The patients were seated 1 meter away from a 17” monitor (19.5°) in the spectacle correction if it was necessary. The mean luminance of the display was 50 cd/m². The contrast between the black and white squares was about 80%. A stimulation pattern of the checkerboard was used in the reversal mode, i.e. black squares were changed into the white ones and vice versa. Stimulation in the on-off mode, where the pattern is alternately switched on and off, may also be used. The patients underwent a clinical protocol with two check sizes:

Conclusion: photocoagulation is an effective method of treatment for active stages of retinopathy of prematurity.
The fly is a test of gross stereopsis (3000 seconds of arc). Children are often tested by being asked to hold one of the wings of the fly, which they will do above the plate if it is seen stereoscopically. The other vectographs in the test provide finer tests of stereoscopic acuity. In the circle test, the degree of disparity ranges from 800 to 40 seconds of arc, in the animal test from 400 to 100 seconds of arc.

Two groups were distinguished among the examined children. The first group was composed of children with stereopsis (at least one of the performed tests was positive). Children without stereopsis or children in whom we were not able to perform the examination (lack of cooperation) were classified into the second group.

**Angle of squint**

The objective and subjective angle of squint was measured with a Clement Clark synoptophore.

**Color vision test**

The “Color Vision Test Made Easy” (CVTME) was included in this study. It is a common screening tool, and it was reported to have high sensitivity and specificity to detect red-green color vision deficiency. It is a test recommended for young children, especially 3-6-year old pre-school children, or mentally disabled people. This pediatric pseudoisochromatic (different colored dots) color vision test contains 14 plates arranged to show a central object (a circle, star, square, and picture card) on which the patient is asked to identify. A color deficient person will only be able to identify some of the figures. Two groups were distinguished among the examined children: a group of children with proper color vision and a group of color deficient children. The third group consisted of children who did not undergo the examination.

**Examination of anterior segment**

We used a slit lamp (biomicroscope) to examine the anterior segment of the eyes. The children were classified into three groups: patients with normal anterior segment, patients with abnormal anterior segment and patients who did not undergo the examination.

**Funds examination**

We used direct and indirect ophthalmoscopy. Fundoscopy was performed after dilation of pupils (15 minutes after instillation of 1% Tropicamide). According to the CRYO-ROP classification, we defined unfavorable structural results when one of the three signs occurred: retinal fold involving macula, retinal detachment in zone 1 or retrolental tissue or “mass” obscuring the view of the posterior pole [17].

**Intraocular pressure examination**

Intraocular pressure (IOP) was measured using a non-contact (NCT) pneumotonometer (NIDEK, NT-200). Each participant's IOP was classified as normal/abnormal based on a statistical norm – 11-21 mmHg. The third group consisted of the children who did not undergo the examination.

**Psychomotor development**

The neurodevelopmental examination was conducted with the use of the Leiter scale and Developmental test of Visual Perception (DTVP).

The Leiter scale is a non-verbal psychometric evaluation containing 52 subtests. The scale is designed for children from 3 to 15 years of age. It is a measure of nonverbal intelligence which includes diverse aspects of cognition, ability to solve novel problems (which are not tied to “school learning” or culturally determined) and a basic level of visual ability. It is an individual test and tasks are very interesting for the child. It was the only standardized test for children aged 4 available in Poland at the time of the study.

The Developmental test of Visual Perception – visual perceptive abilities were examined using the most recent Polish revised version of the classic Marianne Frostig DTVP. All the children were examined using five subtests. In the Eye-motor Coordination test they were asked to draw straight or curved lines according to given boundaries. The Figure-ground test aimed at isolation of simple, defined figures hidden in a complex background. In the Constancy of Shape Test children were asked to find as many partially covered figures as possible. During the Position in Space test the children were shown a stimulus figure and asked to choose a corresponding or different one from a series of figures. Finally, in the Spatial Relationships test children were shown an increasingly complicated line arrangements and asked to copy them. The test rating consists of an overall score and five partial results. The DTVP has been validated and proved to be internally consistent, when compared to other established tools assessing visual perception, such as Beery-Buktenica Developmental Test of Visual Motor Integration (VMI) and Test of Visual Perceptual Skills (TVPS-3) [11]aged 6-12 years, completed the DTVP-2, the Beery-Buktenica Developmental Test of Visual-Motor Integration 6th edition (VMI). The results yield scores including raw values, age equivalents, percentiles, composite quotients that provide insight into...
Anisometropia
Anisometropia larger than 2.0 D occurred in 2 cases (10%) in group 1 and in 7 (20%) cases in group 2 (p=0.05).

VEP examination
The valid results were reached in 71 children. The examination was contraindicated in 7 individuals due to the history of epilepsy, 4 children did not cooperate and were excluded.

Abnormal VEP results were found in 7 children (25%) in group 0, in 4 children (24%) in group 1, and in 14 children (54%) in group 2 (p = 0.044).

Stereopsis
Stereoscopic vision in group 0 presented in 28 cases (93.3%), in group 1 in 18 patients (90%) and in 15 patients (46.9%) in group 2.

Table I
Comparison of selected clinical variables between the studied groups.
Porównanie wybranych zmiennych klinicznych w badanych grupach.

<table>
<thead>
<tr>
<th></th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g)</td>
<td>1229 (192)</td>
<td>1074 (218)</td>
<td>771 (152)</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>29.4 (1.75)</td>
<td>28.5 (1.67)</td>
<td>25.7 (1.77)</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Oxygen therapy (days)</td>
<td>25 (24)</td>
<td>34 (19)</td>
<td>77 (27)</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Intraventricular hemorrhages grade III (IVH)</td>
<td>1 (3.3%)</td>
<td>1 (5.0%)</td>
<td>10 (31.3%)</td>
<td>&lt;0.001#</td>
</tr>
<tr>
<td>Periventricular leukomalacia (PVL)</td>
<td>0 (0.0%)</td>
<td>5 (25%)</td>
<td>6 (18.8%)</td>
<td>0.021#</td>
</tr>
<tr>
<td>Celebral palsy (CP)</td>
<td>2 (6.7%)</td>
<td>1 (5.0%)</td>
<td>4 (12.5%)</td>
<td>0.57#</td>
</tr>
</tbody>
</table>

Table II
Comparison of visual acuity examination between the groups.
Porównanie wyników badania ostrości widzenia pomiędzy grupami.

<table>
<thead>
<tr>
<th></th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual acuity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤0.1</td>
<td>number 0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>percent</td>
<td>0.0%</td>
<td>0.0%</td>
<td>6.3%</td>
</tr>
<tr>
<td>0.2-0.4</td>
<td>number 1</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>percent</td>
<td>3.3%</td>
<td>10.0%</td>
<td>31.3%</td>
</tr>
<tr>
<td>0.5-0.7</td>
<td>number 2</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>percent</td>
<td>6.7%</td>
<td>5.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>0.8-1.0</td>
<td>number 27</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>percent</td>
<td>90.0%</td>
<td>85.0%</td>
<td>37.5%</td>
</tr>
</tbody>
</table>

Table III
Prevalence of refractive errors in the studied groups.
Częstość występowania wad refrakcji w badanych grupach.

<table>
<thead>
<tr>
<th>Refractive error</th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myopia&gt;7D</td>
<td>number 0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>percent</td>
<td>0.0%</td>
<td>5.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Myopia 3-7D</td>
<td>number 0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>percent</td>
<td>0.0%</td>
<td>0.0%</td>
<td>9.4%</td>
</tr>
<tr>
<td>Myopia&lt;3D</td>
<td>number 2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>percent</td>
<td>6.7%</td>
<td>0.0%</td>
<td>28.1%</td>
</tr>
<tr>
<td>Without refractive error</td>
<td>number 0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>percent</td>
<td>0.0%</td>
<td>0.0%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Hyperopia&lt;3D D</td>
<td>number 27</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>percent</td>
<td>90.0%</td>
<td>85.0%</td>
<td>28.1%</td>
</tr>
<tr>
<td>Hyperopia 3-7D</td>
<td>number 2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>percent</td>
<td>3.3%</td>
<td>10.0%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Table IV
Prevalence of strabismus in the studied groups.

<table>
<thead>
<tr>
<th>Strabismus</th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergent ≥10°</td>
<td>number 1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>percent 3.3%</td>
<td>10.0%</td>
<td>28.1%</td>
</tr>
<tr>
<td>Convergent &lt;10°</td>
<td>number 11</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>percent 36.7%</td>
<td>35.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Without strabismus</td>
<td>number 15</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>percent 50.0%</td>
<td>40.0%</td>
<td>40.6%</td>
</tr>
<tr>
<td>Divergent &lt;10°</td>
<td>number 3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>percent 10.0%</td>
<td>15.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Divergent ≥10°</td>
<td>number 0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>percent 0.0%</td>
<td>0.0%</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

Table V
Parental opinion about prevalence of strabismus in the studied groups.

<table>
<thead>
<tr>
<th>Strabismus</th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without strabismus</td>
<td>number 26</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>percent 86.7%</td>
<td>90.0%</td>
<td>56.3%</td>
</tr>
<tr>
<td>Strabismus</td>
<td>number 4</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>percent 13.3%</td>
<td>10.0%</td>
<td>43.8%</td>
</tr>
</tbody>
</table>

Table VI
Comparison of the psychologic tests results between the studied groups.

<table>
<thead>
<tr>
<th>Leitner test (points)</th>
<th>GROUP 0 No ROP (n=30)</th>
<th>GROUP 1 ROP without treatment (n=20)</th>
<th>GROUP 2 ROP required lasertherapy (n=32)</th>
<th>p for ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>102.57 (17.03)</td>
<td>101.50 (18.10)</td>
<td>92.60 (18.93)</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>Frosting test (points)</td>
<td>95.17 (15.31)</td>
<td>97.74 (17.89)</td>
<td>82.37 (16.12)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Neurodevelopmental examination

All the children underwent a Leiter test and a Developmental test of Visual Perception. The analysis of the results of the psychomotor evaluation showed that children in group 2 had significantly lower DTVP scores compared with the children in group 0 and 1. (Table VI).

Discussion

ROP is a major cause of blindness in children in Poland and throughout the world [18,19]. In the 20th century three epidemics of ROP were reported: the first was between 1940-1954 when oxygen therapy was identified as a major causative agent, the second was described during 1960-1970, when improved neonatal care led to an increased survival of ELBW babies; and the third has been going on since 1980 up to this day, as preterm babies of more than 32 weeks of gestational age and a birth weight greater than 1500 grams continue to survive with the neonatal care available in developing countries with limited resources [20].

Preterm birth may have major consequences to the development of the visual pathway. Both ocular and brain pathologies, ranging from local to diffuse, have been implicated in visual defects in preterm children. In our study, the rate of ROP was 63% as compared to two major studies, CRYO Therapy–ROP (CRYO-ROP) and ET–ROP: 65.8% to 68% of newborns with a birth weight <1250 grams develop some degree of ROP [21,22].

We found that there was a significant correlation between ROP occurrence and gestational age, birth weight and duration of oxygen therapy, which is consistent with the findings of the studies performed by Binkhathalan et al, Karkhanah et al, Mutlu et al. and Palmer et al. [23-26].

In our study we found that the mean head circumference (HC) at the age of four was smaller by 1.5 centimeters in group 2 as compared to group 0 and 1. Moreover, the analysis of the results of the psychomotor evaluation showed that children with ROP treated with laser coagulation had significantly lower DTVP scores as compared with the children in group 0 and 1. Similarly, Stathis et al found that poor HC growth between birth and 4 months was associated with impaired 6-year cognition in extremely low birth weight infants [27]. Frisk et al showed that cognition was better in small gestational age (SGA) infants with good postnatal HC growth than in SGA infants with a small HC at birth and at 9 months of age [28]. Brandt et al also found that SGA infants with HC catch-up growth until 1 year of age had higher intelligence scores than those without HC catch-up growth [29].

Very good and good functional results were present in our study in 96.7% in the group of children without ROP, in 90% in the children with ROP without any treatment and in 62.5% in the children with ROP treated with laser coagulation. Comparison of overall visual defects with other studies is problematic because of the differences in the measures used and selection criteria. Previous estimates have been between 15% and 79% for abnormalities detected by...
The predictive value of stereoscopic vision is well known [3,10,53]. The incidence of anisometropia larger than 2.0 D was more common in the group of children with retinopathy of prematurity treated with laser coagulation, but the difference was not statistically significant. A similar observation was presented by Laws et al. [45]. Larsson reports that the development of astigmatism and anisometropia shows a similar course, regardless of a stage of retinopathy of prematurity. He also demonstrates that astigmatism of 1 D or more at 2 years of age and cyotreated severe retinopathy of prematurity are risk factors for astigmatism at 10 years of age, and that anisometropia of 2 D or more at 2.5 years of age is a risk factor for anisometropia at 10 years of age [46]. Cook and Darlow found that the severity ofROP is mostly symmetric in both eyes and it does not increase the incidence of anisometropia [47, 48].

Visual evoked potentials (VEP) are used primarily to measure the functional integrity of the visual pathways. This examination is also used to assess a development of the visual system in prematurely born children. Already in 1987 Taylor et al showed that there are differences in the maturation of the visual system in the extraterus versus intrauterine environment [49].

In 1995, Roy performed VEP study in babies born at full term and preterm, and concluded that this study is very useful to monitor the development of visual function in both groups. [50]

In 2002, Atkinson et al used VEP to evaluate the function of the visual cortex in premature babies with and without neurological disorders, and compared them to term infants. The author showed that VEP can be used as an early predictor of later neurological disorders [51]. Feng et al. showed that VEPs are a convenient non-invasive method that may be useful for the assessment of certain aspects of the development of the eye and brain of infants [52].

In our study the prevalence of abnormal VEP results was highest in the group of children with ROP treated with laser coagulation. The obtained results may indicate that conduction in the visual pathway is damaged in preterm infants with retinopathy of prematurity treated with laser coagulation. The occurrence of strabismus in preterm children [54]. The cause of strabismus in preterm children is unclear. Strabismus may be attributed to ROP, increased refractive errors, anisometropia, immaturity, and neurological impairment [46,55].

In our study, in all the three groups more convergent strabismus cases were observed than divergent ones, but the difference was not statistically significant. In all the children who managed to perform the color vision examination, the test result was valid. Similar results have been obtained in other studies [37].

A diode laser treatment can be associated with complications in the anterior segment of the eye. In our study we found only one child with anterior segment abnormalities possibly related to retinopathy of prematurity.

In our material favorable structural results were observed in 99.6% eyes. These results are slightly better compared with previous studies. Foroozan et al reported favorable structural results in 91% of treated eyes [56]. Steinmetz et al, in 96% of laser coagulation-treated eyes [57]. VLBW children perform significantly worse on a similar problem of neurodevelopmental examination compared to term born infants [58]. Visual-motor impairment can have far-reaching consequences including perceptual, cognitive and mental health disorders [59-62].

The analysis of the outcomes showed that children with retinopathy of prematurity treated with laser coagulation had significantly lower DTVP scores as compared with children in group 0 and 1. The observation is consistent with previous reports. Our study has some limitations: a lack of a control group of healthy term individuals (in our study preterm children without ROP constituted a control group). The study was conducted at a single center: if it were a multicenter study, results could be different. The biggest advantage of the study is fact that it is a multi-faceted, comprehensive ophthalmological examination in combination with psychological research.

Conclusion

Our observations suggest that an important factor affecting a final ophthalmological assessment in prematurity-born children is retinopathy of prematurity treated with laser-coagulation. Moreover, we found that in children with retinopathy of prematurity who did not require treatment the prognosis of the function of the visual system is very close to children without retinopathy of prematurity, and the results of Developmental Test of Visual Perceptions was similar in all three groups.

Early treatment for retinopathy of prematurity (ETROP) is an effective method of treatment for active stages of retinopathy of prematurity and allows for favorable structural and functional results in preterm children. Systematic ophthalmological examination in all preterm infants should be performed due to the risk of complications of prematurity including refraction errors and strabismus.

These disorders must all be recognized early in preterm children. Particularly in patients with retinopathy of prematurity, an early and long-term follow up is important for correct lens prescription to avoid severe amblyopia in adulthood.

References


