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Contrast sensitivity assessment in primary open angle glaucoma and ocular hypertension

Zastosowanie kontrastometrii w diagnostyce jaskry pierwotnej otwartego kąta przesączenia oraz nadciśnienia ocznego

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Abstract: **Introduction:** Contrast sensitivity assessment is an important additional examination, which enables the full insight into the patient's quality of vision, and early diagnosis of visual disturbances.
Material and methods: Forty six patients (92 eyes) with primary open angle glaucoma or ocular hypertension were enrolled in the study. The enrolment criteria were full or almost full visual acuity and the patients with visual field defects or any other ocular disease were excluded. Contrast sensitivity was assessed both under photopic and mesopic conditions (with and without glare) using the Functional Vision Analyzer separately for each eye. Furthermore, the retinal nerve fiber layer (RNFL) thickness was measured using scanning laser polarimetry (GDx).
Results: Contrast sensitivity was significantly reduced under both mesopic and photopic conditions in patients with primary open angle glaucoma or ocular hypertension.
Conclusions: Evaluation of contrast sensitivity is a valuable diagnostic test, which enables the assessment of visual dysfunction in patients with primary open angle glaucoma or ocular hypertension persisting despite good visual acuity.

Key words: contrast sensitivity, primary open angle glaucoma, ocular hypertension.

Abstrakt: **Wstęp:** kontrastometria jest jednym z badań dodatkowych, które umożliwia poznanie całościowego obrazu dotyczącego możliwości wzrokowych pacjenta, a także rozpoznanie zaburzeń widzenia na początkowym etapie zaawansowania.
Pacjent i metody: do badania zakwalifikowano 46 chorych na jaskrę pierwotną otwartego kąta i nadciśnienie oczne, z pełną lub nieznacznie obniżoną ostrością wzroku, u których nie zaobserwowano istotnych zmian w polu widzenia. U wszystkich pacjentów przeprowadzono badanie poczucia kontrastu za pomocą urządzenia Functional Vision Analyzer. Oceniano widzenie nocne bez oślnienia i z oślnieniem (1 lux) oraz widzenie dzienne bez oślnienia i z oślnieniem (10 lux) dla każdego oka oddzielnie. Przeprowadzono także badanie skaningowej polarymetrii laserowej (GDx) z oceną wskaźnika NFI (Nerve Fiber Indicator).
Wyniki: w badaniu stwierdzono istotne obniżenie wrażliwości na kontrast w warunkach widzenia dziennego i nocnego u badanych z grupy chorych na jaskrę i nadciśnienie oczne w odniesieniu do badanych z grupy porównawczej.
Wnioski: badanie poczucia kontrastu jest cennym narzędziem diagnostycznym umożliwiającym poszerzenie diagnostyki i określenie stopnia uszkodzenia funkcjonalnego narządu wzroku u chorych na jaskrę lub nadciśnienie oczne, którzy mają dobrą ostrość wzroku.

Słowa kluczowe: wrażliwość na kontrast, jaskra pierwotna otwartego kąta przesączenia, nadciśnienie oczne.

Introduction

The elevated intraocular pressure is the main risk factor leading to the progressive optic nerve damage in glaucoma. The retinal nerve fiber layer atrophy in glaucomatous neuropathy causes visual field defects (1–3). Visual acuity remains unaltered until glaucoma is advanced. That is why it is insufficient for estimating the progression of glaucoma (4, 5).

According to some researchers, glaucomatous optic nerve damage affects contrast sensitivity to a greater extent than it does the visual acuity (6, 7). Perimetry is a standard examination in diagnosis and monitoring of glaucoma. It enables detecting typical visual field defects. However, it is only possible to detect these typical defects when the ganglion cell count decreases to about 30–50% of its baseline number (8–11).

In practice, different diagnostic methods are used to enable earlier detection of optic nerve damage.

Along with the objective assessment of the optic disc and nerve fiber layer in scanning laser polarimetry (GDx), optic nerve tomography (OCT) or laser scanning ophthalmoscopy (HRT), other additional tests are used, including contrast sensitivity assessment, colour vision assessment and electroretinography (ERG) (2, 11).

Contrast sensitivity assessment is an important additional examination, which enables the full insight into the patient's quality of vision (12). Patients with various ocular pathologies present with an impaired ability to distinguish objects under low contrast, while it remains normal under high contrast.

Contrastometry is used in the assessment of patients with ocular diseases and patients after refractive or cataract

surgery. It is also used in examining patients with neurological dysfunctions and ocular manifestations of systemic diseases, in cases of neurotoxicity and in healthy individuals who require a detailed vision assessment e.g. pilots, drivers.

Material and methods

Patients diagnosed with primary open angle glaucoma (POAG) or ocular hypertension, without significant visual field defects or any other ocular disease, were enrolled in the study. The examined group consisted of 92 eyes of 49 patients (41 men and 8 women), aged from 22 to 73 years old (mean age of 61 years). The enrolment criteria included the full or almost full best corrected visual acuity (BCVA) ranging from 0.6 to 1.0 (mean BCVA = 0.91).

The control group consisted of 49 eyes of 37 healthy subjects (16 women and 21 men), aged from 20 to 81 years old (mean age of 39 years) with full visual acuity, without a history of any ocular disease.

The analysed data was gathered prospectively from a non-randomized consecutive series of patients. All study procedures were compliant with the Declaration of Helsinki. All patients gave an informed consent to participate in the study. The study

protocol was approved by the Internal Review Board (number RNN/53/11/KE).

Before contrastometry, all patients underwent a full ophthalmic examination. The best corrected visual acuity was determined using the standard Snellen’s charts. A slit lamp examination of the anterior segment and ocular fundus was performed. Intraocular pressure was measured using the applanation tonometer. Contrast sensitivity was assessed in all patients both under photopic and mesopic conditions (with and without glare) with Functional Vision Analyzer device (Stereo Optical Co., Inc.) separately for each eye. Distance testing approach was chosen. Patients with refractive errors were examined with appropriate correction. Contrast sensitivity was measured for the following spatial frequencies: 1.5, 3, 6, 12 and 18 cpd (cycles per degree). Additionally, the retinal nerve fiber layer thickness was measured, using scanning laser polarimetry (GDx). The nerve fiber indicator (NFI) was analysed.

Results

A statistically significant difference was observed in the mean contrast sensitivity ($p < 0.001$) between patients with primary open angle glaucoma or ocular hypertension and healthy subjects (Tab. I). In patients with primary open angle

	Spatial frequency (cpd)/ Częstotliwość przestrzenna	Study group/ Grupa badana		Control group/ Grupa porównawcza		Z-test score/ Wartość testu Z	p
		x	SD	x	SD		
Night vision without glare/ Widzenie nocne bez oślnienia	1.5	30.3	11.8	56.0	25.1	6.514	$p < 0.001$
	3	62.2	29.3	104.3	34.7	6.345	$p < 0.001$
	6	29.1	24.5	69.3	33.5	6.739	$p < 0.001$
	12	5.66	7.90	21.4	16.4	6.540	$p < 0.001$
	18	1.11	2.74	4.76	4.48	4.838	$p < 0.001$
Night vision with glare/ Widzenie nocne z oślnieniem	1.5	39.1	19.6	65.7	23.9	5.966	$p < 0.001$
	3	66.8	33.4	109.0	31.2	6.230	$p < 0.001$
	6	28.3	23.8	68.4	30.8	6.971	$p < 0.001$
	12	5.79	8.13	20.9	15.5	6.659	$p < 0.001$
	18	1.18	3.15	4.82	5.13	4.644	$p < 0.001$
Day vision without glare/ Widzenie dzienne bez oślnienia	1.5	36.7	17.3	50.4	19.3	4.224	$p < 0.001$
	3	73.5	34.1	117.1	27.9	6.317	$p < 0.001$
	6	48.5	32.7	108.0	38.7	7.330	$p < 0.001$
	12	18.1	15.8	41.3	24.4	6.393	$p < 0.001$
	18	4.86	7.17	16.2	11.5	6.642	$p < 0.001$
Day vision with glare/ Widzenie dzienne z oślnieniem	1.5	42.4	19.3	64.3	23.6	5.152	$p < 0.001$
	3	85.3	38.9	127.4	26.1	5.732	$p < 0.001$
	6	61.4	38.5	112.3	37.9	6.293	$p < 0.001$
	12	20.4	16.8	47.0	25.8	6.412	$p < 0.001$
	18	5.61	7.74	17.5	12.5	6.336	$p < 0.001$

Tab. I. Comparison of mean contrast sensitivity in different spatial frequencies in various lighting conditions.

Tab. I. Porównanie średnich wartości poczucia kontrastu w różnych częstotliwościach przestrzennych i różnych warunkach oświetlenia.

glaucoma or ocular hypertension, contrast sensitivity was significantly reduced in all spatial frequencies, both under photopic and mesopic conditions (with and without glare) (Fig. 1).

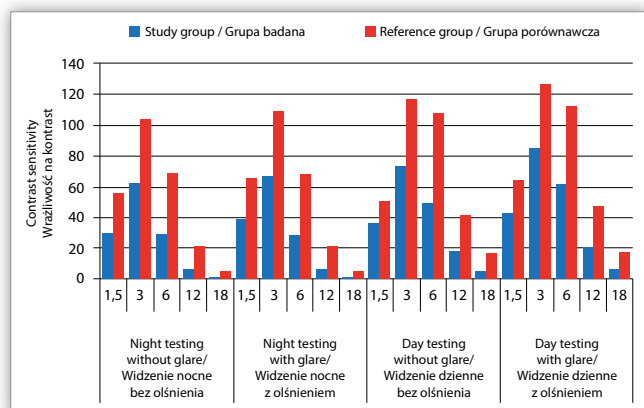


Fig. 1. Comparison of mean contrast sensitivity in different spatial frequencies in various lighting conditions.

Ryc. 1. Porównanie średnich wartości poczucia kontrastu dla różnych częstotliwości przestrzennych oraz różnych warunków oświetlenia.

The results of GDx measurements in patients with glaucoma or ocular hypertension showed the NFI range between 2 and 36 (mean 14.3; SD 8.38). The NFI remained within reference ranges in almost all patients, taking borderline values only in a few cases. The output values classification was based on the following ranges: 1–30 normal, 31–50 borderline, above 51 abnormal.

The NFI examination was based on the entire RNFL thickness map to optimize the discrimination between healthy and glaucomatous eyes. Its sensitivity and specificity has been reported as very high. The statistically significant correlation between the NFI and contrast sensitivity was not confirmed.

Discussion

In various studies, contrast sensitivity deterioration in low, medium and high spatial frequencies under both photopic and mesopic conditions was reported in patients with early and advanced glaucoma (5, 9, 13). Our study confirms these conclusions. The decreased contrast sensitivity in medium spatial frequencies (6 cpd) was significantly correlated with the severity of glaucomatous neuropathy (5). Ross et al. (14) noticed that in glaucoma with advanced neuropathy, the decrease of contrast sensitivity affected all spatial frequencies. On the other hand, the same authors mentioned that in patients with early glaucomatous neuropathy and minor visual field defects, the deterioration of contrast sensitivity affected only medium and high spatial frequencies (14). It indicates that vision at medium and high spatial frequencies is more vulnerable at early stages of glaucoma. Meanwhile, some reports stated that the reduced contrast sensitivity for the low and medium spatial frequencies affected 39% of patients diagnosed with glaucoma (15).

The reduced contrast sensitivity in patients with ocular hypertension or early POAG with good visual acuity is significantly correlated with visual field defects (16–18). The same authors suggested that the reduced contrast sensitivity may be the actual cause for patients complaints about impaired

vision, despite good visual acuity. Furthermore, the correlation between anatomical severity of glaucomatous neuropathy (DDLS Scale or c/d ratio) and the results of contrastometry was identified (5, 18, 19). The results of our study are consistent with the results of previously published articles. However, the relevant conclusion is that the reduced contrast sensitivity may precede perimetric defects (19), which supports the use of contrastometry in glaucoma patients.

Conclusion

Contrast sensitivity testing is a valuable diagnostic tool, which allows to detect the deterioration of visual function in patients with primary open angle glaucoma or ocular hypertension who still have good visual acuity.

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