

Blue-on-yellow perimetry and corneal thickness in patients with ocular hypertension

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Abstract

• **AIM:** To evaluate the frequency of blue-on-yellow perimetry (B/YP) deficits in ocular hypertension (OHT) patients and to correlate these findings with central corneal thickness (CCT), and to investigate the influence of age, refraction and gender on the B/YP results in OHT patients.

• **METHODS:** The B/YP and CCT were checked respectively in 72 OHT patients with normal white-on-white perimetry (W/WP) and normal optic nerve head. The B/YP was tested by Octopus 101 automated perimetry using G2 strategy, while the CCT was checked with DGH-550 ultrasound pachymeter. All patients were chosen randomly one eye for statistical analysis, a binary regression model was used to determine the independent contribution of variables included in the model, and the differences of the intraocular pressure (IOP), CCT, age, refraction and gender between the normal B/YP group and abnormal B/YP group were compared.

• **RESULTS:** Forty-nine out of 72 patients with OHT showed normal B/YP results, whereas 23 of 72 patients (31.9%) demonstrated abnormal B/YP results. CCT showed a correlation with the B/YP results ($B=-0.038$, $SE=0.019$, $P=0.044$), whereas none of the IOP, age, refraction and gender was found to be correlated with the B/YP results. The mean CCT in OHT patients with abnormal B/YP group was lower than that with normal B/YP group ($t=2.066$, $P=0.043$). There was a significant positive correlation between IOP and CCT ($R^2=0.513$, $P=0.000$).

• **CONCLUSION:** The mean CCT in OHT patients with abnormal B/YP results was lower than that with normal B/YP results. There was a significant positive correlation between IOP and CCT in OHT patients. The age, refraction and gender

didn't influence the B/YP results in OHT patients.

• **KEYWORDS:** ocular hypertension; blue-on-yellow perimetry; central corneal thickness; visual function
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INTRODUCTION

Previous works have demonstrated that the detection with blue-on-yellow perimetry (B/YP) can find out visual field defects earlier than that with white-on-white perimetry (W/WP) in patients with glaucoma^[1-8]. Some studies have also suggested that the measured value of intraocular pressure (IOP) is related to the corneal thickness^[5-8]. It was considered that the thick corneas could cause overestimation of the true IOP, and the individuals classified as having ocular hypertension (OHT) with thicker corneas, were less possible to have visual function damage^[9-12]. Relationship between B/YP and central corneal thickness (CCT) values in OHT patients has been reported by others^[13-15]. Medeiros *et al*^[13] and Brusini *et al*^[14] and Dadaci *et al*^[15] found that OHT patients with B/YP abnormalities had significantly lower CCT values when compared with OHT patients without B/YP defects. However, it is unclear whether the B/YP results in OHT patients are influenced by age, refraction and gender. The purpose of our study is to evaluate the frequency of B/YP deficits in OHT patients and to correlate these findings with CCT values, and to investigate the influence of age, refraction and gender on the B/YP results in OHT patients.

MATERIALS AND METHODS

Subjects The study was performed in the Department of Ophthalmology, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine between March 2005 and June 2008. The research followed the tenets of the Declaration of Helsinki, and approval of the study was obtained from the institutional review board of Ruijin Hospital, Shanghai, China. All patients received a detailed explanation of the study, including the necessity for an

examination, after which they provided written informed consent. Seventy-two eyes (37 left eyes, 35 right eyes) of 72 patients with OHT diagnosed by glaucoma clinic of the Department of Ophthalmology at Ruijin Hospital were included in this study. Each patient was randomly selected one eye for study. The mean age of the 34 men and 38 women was 29.83 ± 9.91 years (range 17 ± 57 years). The refractive sphere error ranged from -7 to +2 diopters, and all eyes had a corrected visual acuity no less than 0.8. Color deficiency and other eye diseases and neurological diseases were excluded for all patients. Patients with OHT were identified if they had high IOP measured by Goldmann applanation tonometer (IOP > 21 mmHg without any treatment), normal visual field with conventional W/WP, open angle at gonioscopy, and normal optic nerve head (no optic rim notch or diffuse/generalized loss of optic rim tissue, vertical cup/disc diameter ratio symmetry and no disc hemorrhage) and retinal nerve fiber layer on clinical examination^[9,16].

Methods The blue-on-yellow visual field was performed by Octopus 101 automated perimetry (Interzeq INC, Switzerland) with Normal Program G2 (central 30 degrees). The test parameters for B/YP were as follows: the yellow background luminance was 100 candela/m², Goldmann size V blue stimulus was used for the stimulus target, and the target duration time was 200 milliseconds. The crosshair in the screen provided a central fixation mark. Data analysis was derived from all 59 single data points in the central 30 degrees of the visual field. All patients had a background illumination adaptation for 5 to 10 minutes before visual field examination. All visual field examinations were performed under the natural pupil size. If there was presbyopia present, it was corrected using proper convex lenses. All patients had the experiences of automated visual field examination for at least two times, and one eye of each patient was randomly selected to undergo for one training session before actual test. The results of this training session were discarded. Right eye was tested first, and then left eye with 30 minutes break. The test results were stored in disk and printed. The abnormal B/YP was defined as^[7, 8]: (1) 3 adjacent points depressed by 5 dB, with 1 of the points depressed by at least 10 dB; (2) 2 adjacent points depressed by 10dB; (3) a 10 dB difference across the nasal horizontal meridian in 2 adjacent points. In addition, visual field testing was considered reliable only when reliable factor was less than 15%.

The CCT was measured with an ultrasound pachymeter (DGH-550; DGH technology INC). Repeated sets of three readings were taken until the standard deviation for the three readings was 5 μm or less. The measurement order is similar with blue-on-yellow visual field test.

Table 1 Binary regression model for the entire group

	B	Standard. error	P
IOP	0.177	0.191	0.356
CCT	-0.038	0.019	0.044
Age	-0.011	0.029	0.702
Refraction	-0.038	0.117	0.747
Gender	0.491	0.548	0.370

IOP: Intraocular pressure; CCT: Central corneal thickness; B/YP: Blue-on-yellow perimetry

Statistical Analysis Statistical analysis was performed on computer (SPSS for Windows ver. 11; SPSS, Chicago, IL). Data are expressed as the mean ± SD, otherwise stated. A binary regression model was used to determine the independent contribution of variables included in the model. According to the B/YP results, those OHT patients were divided into two groups (the normal B/YP group and abnormal B/YP group) for further statistical analysis. Independent-samples *t* test was used for the comparisons of IOP, CCT, age and refraction between the normal B/YP group and the abnormal B/YP group. Chi-squared test was used for the comparisons of gender between the normal B/YP group and the abnormal B/YP group. Pearson's correlation analysis was used to analyze the correlation between IOP and CCT. The extent of correlation was determined by the square of correlation coefficient (*R*²), and *R*² > 0.66, 0.66 > *R*² ≥ 0.33 and *R*² ≤ 0.33 were defined as high, moderate and mild correlation respectively. *P* < 0.05 was considered statistically significant.

RESULTS

Among the 72 OHT patients, 49 had a normal B/YP visual field, while the other 23 had an abnormal B/YP visual field which occupied 31.9% (23/72). Among the 23 patients who presented an abnormal B/YP visual field, 7 had a nasal step, 10 had a paracentral scotoma and 6 showed a generalized decrease in light sensitivity.

In the entire sample of subjects, when a binary regression model was used, CCT showed a correlation with the B/YP results (B = -0.038, SE = 0.019, *P* = 0.044). None of the IOP, age, refraction and gender was found to be correlated with the B/YP results (Table 1).

According to the B/YP results, those OHT patients were divided into two groups (the normal B/YP group and the abnormal B/YP group) for further statistical analysis. Table 2 showed the comparisons of clinical characteristics between the normal B/YP group and the abnormal B/YP group. The IOP, age, refraction and gender of the abnormal B/YP group were not significantly different to that of the normal B/YP group (Table 2), whereas the mean CCT of the abnormal B/YP group was significantly thinner than that of the normal B/YP group (*t* = 2.066, *P* = 0.043).

Table 2 Comparisons of clinical characteristics between the OHT patients with normal B/YP and abnormal B/YP

	Normal B/YP group (n=49)	Abnormal B/YP group (n=23)	t or χ^2	P
IOP(mmHg)	25.10±2.14 (23 to 33)	24.65±1.72 (21 to 27)	0.881	0.381
CCT (μ m)	572.51±21.42 (525 to 615)	562.09±16.33 (533 to 592)	2.066	0.043
Age(ys)	29.92±9.97 (17 to 55)	29.65±9.99 (19 to 57)	0.106	0.916
Refraction (D)	-2.31±2.34 (-7 to +2)	-2.53±2.34 (-6.5 to +2)	0.374	0.709
Sex(male/female)	25/24	9/14	0.888 ^a	0.449 ^a

IOP: Intraocular pressure; CCT: Central corneal thickness; OHT: Ocular hypertension; B/YP: Blue-on-yellow perimetry;
^aChi-squared test

A moderate positive correlation was found between IOP and CCT in all OHT patients ($R^2=0.513$, $P=0.000$). A moderate positive correlation was also found between IOP and CCT in the OHT patients with normal B/YP ($R^2=0.596$, $P=0.000$), while a mild positive correlation was found between IOP and CCT in the OHT patients with abnormal B/YP ($R^2=0.262$, $P=0.013$).

DISCUSSION

According to Imbert-Fick theory, the counterforce of the rigidity of the walls of the globe (eye ball) is countervail to the surface tension, thus the thickness of the walls of the eyeball won't affect the IOP measurement by using Goldmann applanation tonometer. But this hypothesis is not applicable to all types of patients. Many studies have already shown that the corneal thickness has a great deal of effect on IOP measurement when using Goldmann applanation tonometer^[9-12]. Doughty *et al*^[17] reported that in children and elderly (geriatric) patients, for every 10% increase of CCT, the value of IOP increased by 1.3mmHg and 2.6mmHg respectively. Our study also showed that a significant positive correlation was found between IOP and CCT in those OHT patients. Lee *et al*^[18] reviewed the current literature and found that normal subjects and primary open angle glaucoma (POAG) patients had a similar distribution of corneal thickness; however, there was a wide variation, ranging from 427 to 716 μ m. Normal tension glaucoma patients had a tendency towards thinner corneas than normal subjects; however, there was an overlap of thickness measurements of more than two-thirds in 95% of patients^[18]. There was a trend for OHT to have thicker corneas than normal subjects, but again there was an overlap of about one-third in 95% of patients^[18].

OHT is considered as a type of the suspected glaucoma. 4.5%-9.5% of patients will develop POAG within five years^[19]. So how to identify which of those OHT patients have a tendency to develop into glaucoma is a hot topic in clinical research. Gordon *et al*^[19] found that the risk factors of OHT developing into glaucoma were old age, a large horizontal and vertical C/D ratio, a higher standard

deviation of Humphrey visual field, high IOP and a thinner CCT, and the thinner CCT was considered as an extremely important factor in predicting OHT developing into POAG. The visual field defects in early stages glaucoma could not be detected by the conventional W/WP when there was less than 20%-40% death of the retinal ganglion cells^[20]. The B/YP is a type of visual field examination technique, which is a combined method of visual field test and color vision test. Previous works had demonstrated that the B/YP was a highly sensitive and highly special method for detecting visual field defects in glaucoma^[1-8]. Polo *et al*^[21] reported that among 58 OHT patients with the abnormal B/YP, 11 would develop into abnormal W/WP in 3 years. Those results indicated that B/YP could be used to detect the visual field defects in the earlier stages of glaucoma and could be used to predict the visual function development for the OHT patients. If B/YP and CCT could be combined together, it would be a more valuable prediction factor in the visual field function development for the OHT patients. Our present study also showed that the mean CCT of the abnormal B/YP group was significantly thinner than that of the normal B/YP group in OHT patients.

Johnson *et al*^[22] reported that the B/YP results in OHT patients were associated with other risk factors, especially the vertical cup-to disc ratio and age. However, our study showed the B/YP results in OHT patients were not found to be correlated with the age, maybe it was due to a narrow age range (17-57 years) in our OHT patients. There is no data available concerning the B/YP results in OHT patients is influenced by refraction and gender. Our results showed that the refraction and gender were not found to be correlated with the B/YP results.

Kass *et al*^[19] found out from a follow up survey of 1636 OHT patients that the 9.5% of the OHT patients without any lowering IOP treatment would develop into POAG in 5 years, while 4.5% of the patients with lowering IOP treatment would develop POAG in 5 years. This indicated that the morbidity of POAG in OHT patients could be decreased by lowering IOP treatment. If OHT patients with

abnormal B/YP and a thinner CCT are treated, it can decrease or postpone the POAG occurrences, but further research is needed in this aspect.

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