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Distribution of Mean, Systolic and Diastolic Ocular Perfusion Pressure in Telemedical Homemonitoring of Glaucoma Patients

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Key Words

Ocular perfusion pressure · Glaucoma · Ocular tonometry · Telemedicine

Abstract

Background: To analyze the relation and distribution of mean, systolic and diastolic ocular perfusion pressure (OPP) in telemedical homemonitoring of patients with primary open-angle glaucoma (POAG). **Methods:** 70 patients with POAG measured intraocular pressure (IOP) and blood pressure at home for a period of 6 months with the Goldmann applanation self-tonometer Ocuton S and the blood pressure device bosomedicus PC. Twenty-four-hour profiles were taken every 4 weeks in addition to single measurements in the morning and evening once a week. All measured values were transmitted to an electronic patient record, which calculated OPP by taking systolic, diastolic and mean arterial blood pressure and subtracting IOP. **Results:** We analyzed 3,282 values of mean, systolic and diastolic OPP. The quantity of values below the risk levels of the Barbados Eye Studies was calculated. We found values lower than the risk levels for LE: 49 (1.5%)/RE: 60 (1.8%) systolic OPP, LE: 1,623 (49.5%)/RE: 1,761 (53.7%) diastolic OPP and LE: 687 (20.9%)/RE: 794 (24.2%) mean OPP. The individual average OPP levels of all 70 patients below the risk levels showed the following distribution: LE: 4 (5.7%)/RE: 6 (8.6%) systolic OPP, LE: 19 (27.1%)/RE: 20 (28.6%) diastolic OPP and LE: 10 (14.3%)/RE: 10 (14.3%) mean OPP. **Conclusion:** The individual distribution of

different OPP values in POAG patients is not easy to interpret for clinical ophthalmologists. Precise practicable guidelines for clinical use still have to be determined.

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Introduction

Age and genetic predisposition are the main risk factors for glaucoma development and progression [1]. While these parameters do not have interventional potential, the only parameter subject to treatment is intraocular pressure (IOP). However, there is evidence that single IOP measurements as therapeutic parameter are insufficient because we observe both: individuals with elevated IOP without glaucomatous retinal changes (ocular hypertension) and individuals with normal IOP who develop glaucoma (normal-tension glaucoma). Furthermore, there are patients who develop glaucoma progression despite optimal treatment with successful intraocular depression [2–4]. Several studies reported about the vascular role in the pathogenesis of primary open-angle glaucoma (POAG) [5–11]. As a result the impact of blood pressure and ocular perfusion pressure (OPP) on glaucoma has received greater attention as evidence mounts [12]. OPP can be calculated approximately by taking blood pressure and subtracting IOP. It can be broken down to mean, systolic and diastolic OPP. Patients with OPP values lower than levels determined in the Barbados Eye Studies have high-

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Table 1. OPP measurements of 70 POAG patients in telemedical homemonitoring

	Relative risk	Patients with individual average OPP values below risk levels (n = 70 POAG patients)		OPP values below risk levels derived from all self-measurements of 70 POAG patients (n = 3,282)	
		LE	RE	LE	RE
Systolic OPP (<98 mm Hg)	2.0 (1.1/3.5)*	4 (5.7%)	6 (8.6%)	49 (1.5%)	60 (1.8%)
Diastolic OPP (<53 mm Hg)	2.1 (1.2/3.9)*	19 (27.1%)	20 (28.6%)	1,623 (49.5%)	1,761 (53.7%)
Mean OPP (<40 mm Hg)	2.6 (1.4/4.6)*	10 (14.3%)	10 (14.3%)	687 (20.9%)	794 (24.2%)

Figures in parentheses are 95% confidence intervals or percentages as indicated. Percentage of values below risk levels of the Barbados Eye Studies [11]; * p < 0.05.

er risk levels of glaucoma progression (table 1). To evaluate clinical relevance and practicability of those different risk levels we analyzed mean, systolic and diastolic OPP values of 70 POAG patients in telemedical homemonitoring.

Methods

This observational study was conducted in a German population of white European ethnicity. The data presented in this study is based on self-measurements of 70 patients with POAG (33 females, 37 males). The average age of all 70 patients was 60.3 ± 9.6 years (mean ± SD). All participants were volunteers and gave their written consent to take part in this study. Local ethics committee approval was obtained to carry out this study.

Sixty-four subjects received glaucoma medications: 45 applied eyedrops as monotherapy while 21 required a combination of drugs. Four subjects did not take any glaucoma drugs after surgical treatment. Forty-six subjects were treated with antihypertensive drugs: 20 received a monotherapy while 26 required a combination of drugs. Blood pressure-lowering treatment was effective for all 46 patients. Other associated disorders were distributed as follows: type 1 diabetes was present in 2 subjects while 17 subjects had type 2 diabetes. Cardiovascular diseases were reported in 26 subjects.

Glaucoma progression was examined with visual field testing and retinal tomography of the optic nerve head at the beginning and after 6 months at the end of the study. There were neither visual field changes in standard perimetry (TOP strategy, program tG2, Octopus 101; Haag-Streit AG, Switzerland) nor significant changes in optic nerve head parameters (Heidelberg Retina Tomograph II; Heidelberg Engineering GmbH, Heidelberg, Germany) so that glaucomatous optic neuropathy was considered stable for all subjects.

For a period of 6 months all patients performed self-measurements of IOP and blood pressure at home and subsequently transmitted the data via a telemedical interface to a server in the hospital. The data was stored in electronic patient records, which were accessed by the ophthalmologists using a web front end [13, 14]. The patients measured IOP with the Ocuton S (EPSa GmbH, Saalfeld, Germany), a self-tonometer using the Goldmann applanation principle [15]. Central corneal thickness was determined in all subjects with conventional laser pachymetry to adjust all IOP mea-

surements of the Ocuton self-tonometer using the Dresden correction table [16]. Other biomechanical parameters of the cornea were not examined. Blood pressure was measured at the upper arm with the boso medicus PC (Bosch + Sohn GmbH u. Co. KG, Jungingen, Germany), a fully automatic, 1-button-operated oscillometric device, which was graded A/A for BHS protocol and achieved AAMI criteria [17]. We handed out a measuring schedule, which instructed the probands to check blood pressure and IOP in the morning and evening once a week and in addition to perform 24-hour profiles every 4 weeks. In our study, the probands measured pressures 7 times a day at 6 a.m., 9 a.m., noon, 3 p.m., 6 p.m., 9 p.m. and midnight to perform a 24-hour profile. The majority of the probands decided to perform even more measurements than requested. All of the additional measurements were recorded and also included into data analysis. The electronic patient record automatically calculated OPP values using the formula:

$$mOPP = \frac{2}{3} \cdot \left(\frac{2}{3} \cdot DBP + \frac{1}{3} \cdot SBP \right) - IOP$$

$$sOPP = SBP - IOP$$

$$dOPP = DBP - IOP$$

with *mOPP* = mean ocular perfusion pressure, *sOPP* = systolic ocular perfusion pressure, *dOPP* = diastolic ocular perfusion pressure, *DBP* = diastolic blood pressure, *SBP* = systolic blood pressure and *IOP* = intraocular pressure.

Results

The quantity of all 3,282 mean, systolic and diastolic OPP values lower than the Barbados Eye Studies risk levels [11] was distributed as follows: LE: 49 (1.5%)/RE: 60 (1.8%) systolic OPP, LE: 1,623 (49.5%)/RE: 1,761 (53.7%) diastolic OPP and LE: 687 (20.9%)/RE: 794 (24.2%) mean OPP.

Furthermore, we regarded the individual average OPP values of all 70 POAG patients. The quantity of patients which had OPP values below the Barbados Eye Studies risk levels [11] showed the following distribution: LE: 4 (5.7%)/RE: 6 (8.6%) systolic OPP, LE: 19 (27.1%)/RE: 20 (28.6%) diastolic OPP and LE: 10 (14.3%)/RE: 10 (14.3%)

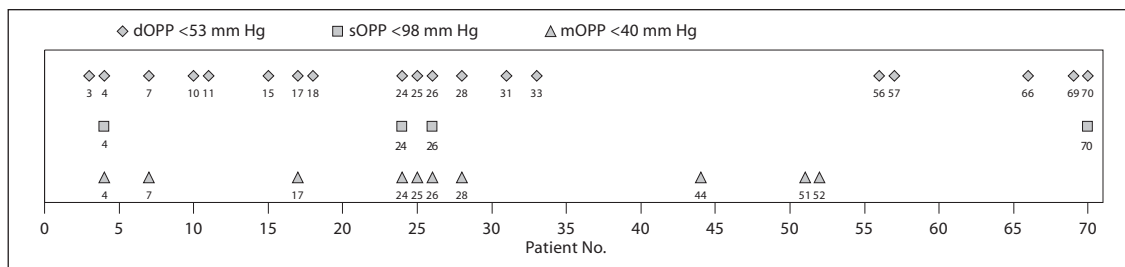


Fig. 1. Matrix of individual OPP means in 70 left eyes of POAG patients in telemedical homemonitoring. For each individual the symbols indicate which OPP parameters were below risk levels of the Barbados Eye Studies [11]; d, s, m = diastolic, systolic and mean, respectively.

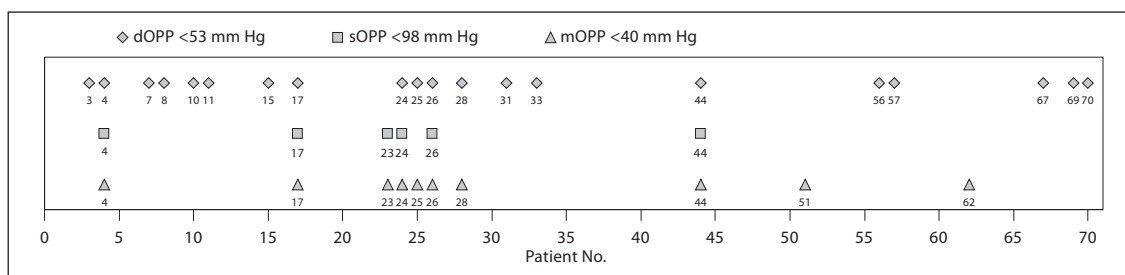


Fig. 2. Matrix of individual OPP means in 70 right eyes of POAG patients in telemedical homemonitoring. For each individual the symbols indicate which OPP parameters were below risk levels of the Barbados Eye Studies [11]; d, s, m = diastolic, systolic and mean, respectively.

mean OPP. An overview of all mentioned parameters and the corresponding risk levels is given in table 1.

A graphical matrix was used to visualize the individual glaucoma progression risk: for every patient we indicated which of the 3 different OPP parameters was below the Barbados Eye Studies risk levels. Figure 1 shows the matrix of the left eyes; the right eyes are presented in figure 2. In 3 of the patients (Id 4, 24, 26) both eyes had low levels for all OPP values. One patient (Id 44) had low levels for all 3 OPP values only in the right eye while the left eye was only below for mean OPP. Combinations of two different values were infrequent (LE: 4/RE: 1) and appeared to be heterogeneous. Single mean OPP lowering was detected in 3 LE/2 RE and single diastolic OPP lowering in 11 LE/13 RE. We did not find any patients with single systolic OPP lowering.

Discussion

The vascular role in glaucoma pathophysiology has been studied intensely, but the etiology of POAG still remains unclear and relations between risk factors appear

to be controversial. Newer studies conclude that ocular perfusion pressure is strongly associated with glaucoma especially in persons with hypertension and hypertensive therapy [18]. This evidence is supported by the results of Waliszek-Iwanicka et al. [19] who concluded that arterial hypertension in glaucoma patients significantly reduced microcirculation in the area of posterior ciliary arteries. In normal-tension glaucoma patients, no significant differences in mean or fluctuation of mean OPP between two groups of normal-tension glaucoma patients and nonglaucoma controls were found [20]. On the other hand, the Los Angeles Latino Eye Study showed that low systolic, diastolic and mean perfusion pressures were associated with a higher prevalence of open-angle glaucoma [21]. The Barbados Eye Studies [11] determined different levels of low OPP for mean, systolic and diastolic OPP and published the according relative risk for glaucoma progression (table 1). These results underline the clinical importance of this diagnostic parameter. However, our findings showed that it is not easy for a clinical ophthalmologist to interpret the data. The distribution of all 3 different OPP values showed widespread variations from less than 2% for systolic OPP up to about half of all values

for diastolic OPP (LE: 49.5%/RE: 53.7%). We also found a heterogeneous distribution for individual average OPP values (table 1), which is visualized graphically in an OPP level matrix for all 70 patients (fig. 1, 2).

Conclusions

As a consequence the complex dynamics and relations of ocular perfusion pressure have to be evaluated in population-based studies in order to determine guidelines for clinical ophthalmologists. We already find strong evidence in other studies but we still miss precise recommendations how to include OPP into a therapeutic regimen. To achieve this, more effort has to be spent on this topic. The interactions and diurnal dynamics of IOP have been studied in detail: we compared a Medline search with the

search strings ‘intraocular pressure’ AND ‘diurnal variation’ with ‘ocular perfusion pressure’ AND ‘diurnal variation’ and found 125 results for IOP and only 6 hits for the latter. Telemedical homemonitoring may provide one feasible way to improve our knowledge about OPP.

Acknowledgement

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Disclosure Statement

The authors declare that they have no conflict of interest.

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