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ORIGINAL ARTICLE

Comparison of three-point and six-point diurnal intraocular-pressure curves

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ABSTRACT

Objective

This study determined if three-point and six-point diurnal intraocular-pressure (IOP) curves are comparable in terms of sensitivity, specificity, and accuracy in detecting swings in IOP measurements of 6 mm Hg or higher.

Methods

This is a retrospective cross-sectional study of 214 glaucoma patients (428 eyes) who underwent six-point diurnal IOP testing. The investigators reviewed their records and generated two sets of data—one for six-point and another for three-point IOP measurements. Diurnal curves were constructed and compared for each set of measurements using univariate analysis of variance.

Results

There was no statistically significant difference ($p < .001$) between three-point and six-point IOP measurements in detecting IOP swings of 6 mm Hg or higher. The three-point determination has a comparable sensitivity of 70.9%, specificity of 100%, and accuracy of 87.6%. However, there is a likelihood for the IOP change to be underestimated by 1.2 mm Hg in a three-point determination.

Conclusion

The three-point determination (9 p.m., 1 p.m., and 5 p.m.) produces a diurnal curve similar to that of a six-point determination and can be used as a tool in detecting IOP swings in glaucoma patients.

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THE DETERMINATION of diurnal intraocular-pressure (IOP) curve, or phasing, is indispensable in the diagnosis and monitoring of patients with normal-tension glaucoma and ocular hypertension, patients with suspicious looking discs without apparent IOP elevation, and diagnosed glaucoma patients who show progressive nerve damage despite apparent control of IOP in the clinic.

The best method of detecting peaks in diurnal curves is a 24-hour inpatient IOP monitoring. Initially, this was done to determine the diurnal curve in normal and glaucomatous patients.[1-6] It also provides an accurate measure of the effectiveness of therapy because compliance is ensured.[7-10] It is, however, not practical in the clinical setting as it interferes with sleep, and the hospital environment is thought to influence or alter the magnitude of physiologic IOP variation in some patients. IOP was found to be significantly lower in hospitalized patients because of inactivity.[11] An alternative is a phasing procedure wherein IOP is measured at regular intervals during clinic hours.[12] This was found to be adequate in detecting peak IOP and IOP swings.

At the University of the Philippines-Philippine General Hospital (UP-PGH) glaucoma clinic, the diurnal curve is determined by measuring the IOP at six points—every 2 hours during clinic hours from 7 a.m. to 5 p.m. Several clinical studies have shown that the probability of pressure peaks occurring during this period ranges from 64 to 80%.[13-17] Clinical trials on newer topical antiglaucoma medications were done using this mode of diurnal-curve determination.[18, 19] However, it is still tedious for patients who have to stay in the clinic for prolonged periods. This artificial environment may also result in an underestimation of the true IOP curve.

Some clinicians use a modified office-phasing procedure by taking the IOP at longer intervals and allowing patients to leave the office while waiting for the next determination. Although more practical because it does not require drastic modification of patient activity, the clinical usefulness of this method needs to be evaluated. It is important to assess whether modified phasing would produce a diurnal curve comparable to that of standard phasing.

This study compared the diurnal IOP curves generated from a three-point IOP measurement (modified office phasing) with a six-point IOP measurement (standard office phasing) from the same set of patients. We determined the sensitivity, specificity, and accuracy of the modified office-phasing procedure in detecting IOP swings of 6 mm Hg or higher.

METHODOLOGY

All patients who were subjected to a six-point IOP determination (7 a.m., 9 a.m., 11 a.m., 1 p.m., 3 p.m., 5 p.m.) at the PGH glaucoma clinic from January 2000 to August 2001 were included in the study. Inclusion criteria were as follows: glaucoma suspects, normal-tension glaucoma, ocular hypertension, primary and secondary open-angle glaucoma, primary and secondary angle-closure glaucoma, with or without medications, pre- or postsurgery. Patients without any record of phasing procedure were excluded.

The investigators reviewed the records of the eligible patients. A precoded data collection tool was made to address the study objectives. Data gathered included age, sex, angle type, medications, surgical procedures, date of phasing, and IOP measurements for both eyes. These were entered into a computer database along with the six-point applanation tonometry (Goldmann, Haag-Streit, Bern, Switzerland) readings. A separate set of data taking only three of the six readings (9 a.m., 1 p.m., and 5 p.m.) was constructed. The corresponding diurnal curves were generated for each patient. Figure 1 shows a sample diurnal curve from a six-point IOP determination while Figure 2 shows its derived three-point curve.

The significant IOP swing was defined as a difference of 6 mm Hg or higher between the highest and lowest IOP value detected by each method of diurnal IOP-curve determination.

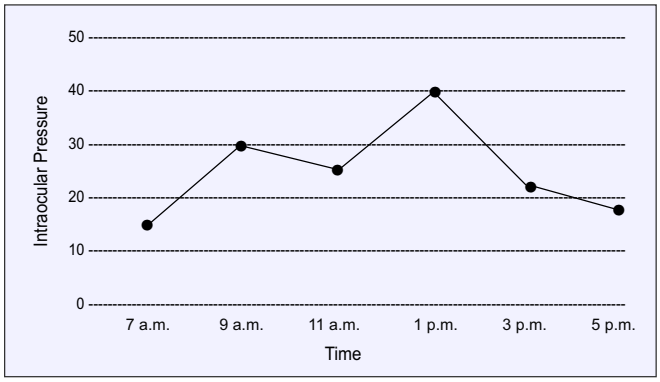

Figure 1. Sample diurnal IOP curve from six-point determination.

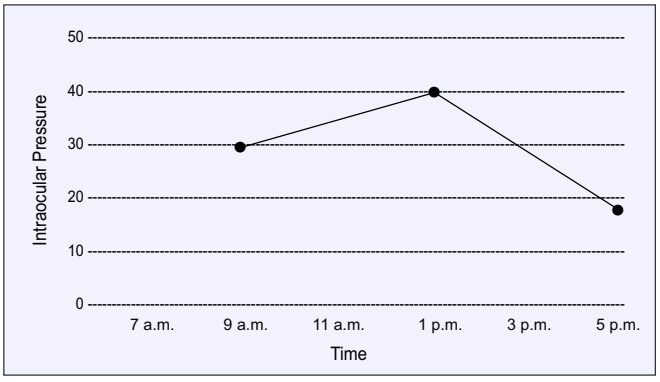

Figure 2. Sample diurnal IOP curve from three-point determination.

Univariate analysis of variance (p = .01) was used to determine whether the curve produced by a three-point determination would approximate that of a six-point determination. The sensitivity, specificity, and accuracy were also determined. Kappa statistics were computed to determine whether the results were due to chance alone. Pearson correlation coefficient was determined to establish linearity of the relationship between the two diurnal curves.

RESULTS

A total of 214 patients (428 eyes) ages 10 to 88 years (mean of 61), 55.6% female, was included in the study. 66.8% had open-angle glaucoma, 9.3% angle-closure, and 23.8% intermittent angle-closure glaucoma. 37.9% of the right and 42.1% of the left eyes were on medications. More than half of the right(55.6%) and left (52.3%)eyes underwent glaucoma surgery.

Table 1 shows the mean and standard deviation of the different IOP measurements in a six-point determination. Table 2 shows the range of IOP swings at each measurement.

There is no statistically significant difference (p< .001) in the ability of each method in determining IOP swings of 6 mm Hg or higher. The three-point determination showed sensitivity of 70.9%, specificity of 100%, and accuracy of 87.6% (Table 3). The kappa value was 0.74 and Pearson correlation coefficient was 0.98.

DISCUSSION

Although IOP is not the only risk factor for the progression of optic neuropathy in glaucoma, it is currently the only factor that can be controlled. Studies have shown that the degree of IOP fluctuation contributes significantly to optic-nerve-damage progression more than the level of IOP at a particular office visit. Gonzales et al. reported that significant IOP fluctuations occurred in 64% of cases who developed visual- field loss.[20] Asrani et al.[21] showed that in glaucoma patients with office IOP in the normal range, large fluctuations in diurnal IOP are risk factors for progression independent of parameters obtained in the office. The Advanced Glaucoma Intervention Study[22] unraveled the protective role of persistently low IOP in visual-field deterioration. Therefore, the documentation of IOP fluctuation plays a vital role in the management of glaucoma patients. This is achieved through diurnal IOP-curve determination.

Univariate analysis of variance for the two sets of data showed a statistically significant similarity in the curves. There is a strong positive correlation (r = 0.98) between the two curves. However, there is a likelihood for the IOP change to be underestimated by 1.2 mm Hg in a three-point determination.

The sensitivity, specificity, and accuracy of the three-point IOP determination are fairly accurate in detecting IOP swings of 6 mm Hg or more. Its kappa value was very good, indicating that the similarity between the two curves was not due to chance.

The results of this study are consistent with those in studies using conventional office diurnal measurements. Collectively, these studies showed that the probability of pressure spikes during office hours (8 a.m. to 5 p.m.) ranged from 64% to 80% (Table 4), and stressed the importance of varying office visits to detect these IOP swings. From these different office visits wherein the IOPs were taken at different times of the day, a diurnal curve can be constructed, providing additional information on

Table 1. **Mean IOP at each time period in a six-point determination.**

Time	Right Eyes (n = 214)	Left Eyes (n = 214)
7 a.m.	15.68 ± 7.14	14.75 ± 5.46
9 a.m.	15.56 ± 7.12	14.56 ± 5.50
11 a.m.	15.15 ± 7.59	14.13 ± 5.27
1 p.m.	15.58 ± 8.19	14.24 ± 5.58
3 p.m.	14.94 ± 7.37	14.10 ± 5.56
5 p.m.	14.46 ± 6.39	13.87 ± 5.39

Table 2. **Range of IOP swings (mm Hg) at each time period in a six-point determination.**

Time	Right Eyes (n = 214)	Left Eyes (n = 214)
7 a.m.	0-12	5-12
9 a.m.	0-14	4-10
11 a.m.	0-10	1-12
1 p.m.	0-12	3-12
3 p.m.	1-12	3-12
5 p.m.	0-12	3-12

Table 3. **Two-by-two table for three-point determination.**

	Six-Point Determination IOP Swing ≥ 6mm Hg	Six-Point Determination IOP Swing < 6mm Hg	Total
Three-Point Determination IOP Swing Positive	129	0	129
Three-Point Determination IOP Swing Negative	53	246	299
Total	**182**	**246**	**428**

Table 4. **Probability of IOP swings in studies using conventional office phasing.**

Study	Probability of IOP Swing (Percent)	Time When Most IOP Swings Occurred
David et al.[13]	65	9 a.m. - 12 nn
Yamagami[17]	78	8 a.m. - 4 p.m.
Rota-Bartelink[15]	80	5 p.m.
Pointer[14]	64	12 nn
Sacca[16]	65	8 - 10 a.m.

the range of IOPs and peak IOPs. Information on when the glaucoma medications were instilled should also be available to address the adequacy of IOP control.

We chose 9 a.m., 1 p.m., and 5 p.m. as our three-point determination based on the common clinic hours of ophthalmologists and the even intervals between these hours. Further studies determining the best possible combination of these hours and the optimum number of hours needed to detect maximum IOP swings can be done.

In summary, the three-point determination (9 a.m., 1 p.m., 5 p.m.) produces a diurnal curve similar to that generated from a six-point determination and can be used as a tool in detecting IOP swings in diagnosed glaucoma patients in an outpatient setting. This study suggested that it is fairly accurate and convenient.

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