24-HOUR INTRAOCULAR PRESSURE IN SUBJECTS WITH PRIMARY OPEN-ANGLE GLAUCOMA: A POPULATION-BASED ASSESSMENT

Dr Chandrima Paul, Prof Himadri Datta, Prof Gautam Bhaduri

Abstract

Purpose. To assess the distribution of the 24-hour intraocular pressure (IOP) in subjects with primary open-angle glaucoma (POAG) in a population-based study in rural West Bengal.

Methods. All untreated POAG patients (n = 132) identified by a door to door survey in the Hugli District of West Bengal were invited to attend a follow-up study in which IOP was tested with a Goldmann Applanation tonometer at 10 AM, 1 PM, 4 PM, 7 PM, 10 PM, 1 AM, and 6 AM.

Results. 72 subjects with untreated POAG (72/132; 88.6%) attended the study. Of them, 59 (83.0%) had a peak IOP ≤ 21 mm Hg. The peak IOP (mean ± SD) was 16.4 ± 4.2 mm Hg. Peak IOP occurred in early morning in approximately 78.5% of the subjects (6 AM to 10 AM), and the trough occurred during night time in 72.2% of the subjects (10 PM to 1 AM). The 24-hour IOP (mean ± SD) was 14.2 ± 4.4 mm Hg and the mean fluctuation was 4.0 ± 6.8 mm Hg (range, 2–11 mm Hg). In the 32 persons with unilateral glaucoma, no significant differences were found in mean 24-hour IOP, peak IOP, trough IOP, or IOP fluctuation when comparing the glaucomatous eye with the non-glaucomatous eye (P > 0.05).

Conclusions. Twenty-four–hour IOP was similar between glaucomatous and Controls (contralateral nonglaucomatous) eyes suggesting that factors other than IOP may play a role in the development of glaucomatous optic neuropathy in these eyes.

Keywords: IOP, POAG, Goldman Applanation tonometer, VCDR
INTRODUCTION

Intraocular pressure (IOP) is the only known modifiable risk factor for primary open-angle glaucoma (POAG).\(^1\)\(^4\) Several population-based studies in Asia have reported that the majority of subjects with POAG have an IOP in the “normal” range. Ninety-two percent of those found to have POAG had IOP < 21 mm Hg in a large study from Japan.\(^5\) However, all these population-based studies estimated this proportion based on a screening and/or a follow-up IOP measurement.

To characterize more precisely the IOP, among a population-based sample with POAG, we conducted a 24-hour IOP measurement on persons diagnosed with POAG in the door to door survey for glaucoma done in the Hugli District of West Bengal and report on the fluctuation range of 24-hour IOP.

Material and Methods

The rural study area consists of 28 contiguous villages from the district of Hugli in West Bengal, India. A door to door field survey in this area recruited glaucoma patients who were diagnosed at the base hospital at Dhobapara, in Village Bakulia which is about 20kms from the study area. The PAOG patients were requested to revisit the base hospital for a 24-hour IOP measurement. POAG was diagnosed according based on criteria described by the International Society for Geographic and Epidemiological Ophthalmology.

All eligible individuals were scheduled for a detailed eye examination and questionnaire interview, which were performed in a standardized manner. The examination included visual acuity, autorefraction, and subjective refraction; questionnaires, anterior segment examination with a slit lamp; intraocular pressure (IOP), gonioscopy, dilated examination, and evaluation of optic disc using +78D lens. The VCDR was recorded and special note made of peri papillary atrophy and optic disc/ peripapillary hemorrhage. Visual field Analysis with HFA 750i using the 24-2 Sita Standard programme was done.

IOP was measured using the Goldman Applanation tonometer (Haagstreit International AT 900) after topical anesthesia. IOP was measured twice, and a third measurement was performed if the difference between two measurements was > 2 mm Hg with the mean of the two closest results used as the IOP measurement. The tonometer was calibrated weekly before examination.

Central corneal thickness (CCT) was obtained using ultrasound pachymetry, after instillation of 2 drops of 0.5% proparacaine for topical anesthesia (Alcon Laboratories, Inc., Fort Worth, TX). The pachymeter probe was placed on the center of the cornea, and the average of five readings was used.

Clinical Cup/Disc Ratio Grading

The optic nerve was evaluated using a 78 D or 90 D lens at ×16 magnification after pupil dilation. The vertical cup-to-disc ratio (VCDR) was used as the key index of structural
glaucomatous change. Measurement of VCDR excluded peripapillary atrophy and the scleral ring of Elschnig.

All included patients had 360 degrees open angles on gonioscopy.

**Twenty-Four–Hour IOP Measurement**

IOP was recorded at 10 AM, 1 PM, 4 PM, 7 PM, 10 PM, 1 AM, and 6 AM. Patients were allowed to sleep between measurements of IOP. IOP was measured with the Goldmann Applanation Tonometer in an upright sitting position. Two measurements were obtained; if the measurement differed by 2 mm Hg or more, a third measurement was obtained and the two closest measurements were averaged to calculate the final IOP.

**Statistical analysis**

To compare the IOP parameters and clinical parameters between glaucoma eyes and contralateral non glaucomatous eyes in the unilateral diagnosed patients, paired t-tests were used. P values < 0.05 were considered to be significant.

For peak IOP analysis, we used the eye with glaucoma if the person had unilateral glaucoma, and we used the eye with the higher peak IOP if the person had bilateral glaucoma. The other parameters of diurnal IOP, such as trough IOP, were calculated using the same eye. Fluctuation was defined as peak IOP minus trough IOP.

**Results**

72 subjects with untreated POAG (72/132; 88.6%) attended the study. Of them, 59 (83.0%) had a peak IOP ≤ 21 mm Hg. The peak IOP (mean ± SD) was 16.4 ± 4.2 mm Hg. Peak IOP occurred in early morning in approximately 78.5% of the subjects (6 AM to 10 AM), and the trough occurred during night time in 72.2% of the subjects (10 PM to 1 AM). The 24-hour IOP (mean ± SD) was 14.2 ± 4.4 mm Hg and the mean fluctuation was 4.0 ± 6.8 mm Hg (range, 2–11 mm Hg). In the 22 persons with unilateral glaucoma, no significant differences were found in mean 24-hour IOP, peak IOP, trough IOP, or IOP fluctuation when comparing the glaucomatous eye with the non glaucomatous eye (P > 0.05).

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**Table 1:** Characteristics of Participants and Controls for 24-Hour Intraocular Pressure Study

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Participants (n = 132)</th>
<th>Controls (n = 60)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>32 (58.2)</td>
<td>28 (60.20)</td>
<td>0.767</td>
</tr>
<tr>
<td>Age, y</td>
<td>58.7 ± 10.6</td>
<td>64.1 ± 8.8</td>
<td>0.024</td>
</tr>
<tr>
<td>Hypertension</td>
<td>30 (70.2)</td>
<td>19 (84.2)</td>
<td>0.337</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5 (8.5)</td>
<td>4 (21.1)</td>
<td>0.149</td>
</tr>
<tr>
<td>CCT, μm</td>
<td>530.5 ± 20.7</td>
<td>520.1 ± 22.4</td>
<td>0.259</td>
</tr>
</tbody>
</table>
Characteristics | Participants (n = 132) | Controls (n = 60) | P
--- | --- | --- | ---
IOP, mm Hg | 16.4 ± 4.2 | 14.2 ± 4.4 | 0.690
VCDDR | 0.7 ± 0.2 | 0.6 ± 0.1 | 0.642
MD, dB | −9.9 ± 6.3 | −8.2 ± 9.1 | 0.469

The mean of average IOP of the diurnal IOP was 16.4 ± 4.2 mm Hg, with the lowest average IOP recorded at 10 PM (14.2 mm Hg) and the highest at 10 AM (23.8 mm Hg) (Fig. 1/Table 2). The mean peak IOP at any time point was 18.6 ± 3.8 mm Hg and the minimum was 12.2 ± 3.6 mm Hg. 78.5% of the patients had a peak IOP less than or equal to 21 mm Hg, and 72.2% of the patients had a peak IOP ≤ 24 mm Hg (Fig. 2). The peak IOP occurred outside of office hours (8 AM to 5 PM) in 32.8% of the subjects and the trough occurred outside of office hours in 74.2% of subjects.

Table 3.
Twenty-four-Hour IOP and Clinical Parameters in Patients with Unilateral POAG (n=32) (Paired t-Tests)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Glaucomatous Eye</th>
<th>Nonglaucomatous Eye</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twenty-four-hour IOP, mm Hg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average IOP, mm Hg</td>
<td>16.2 ± 4.2</td>
<td>16.2 ± 4.1</td>
<td>0.960</td>
</tr>
<tr>
<td>SD, mm Hg</td>
<td>2.2 ± 1.0</td>
<td>2.3 ± 0.7</td>
<td>0.650</td>
</tr>
<tr>
<td>Peak IOP, mm Hg</td>
<td>18.4 ± 4.6</td>
<td>17.6 ± 4.2</td>
<td>0.650</td>
</tr>
<tr>
<td>Trough IOP, mm Hg</td>
<td>12.3 ± 3.6</td>
<td>12.0 ± 3.2</td>
<td>0.620</td>
</tr>
<tr>
<td>Fluctuation, mm Hg</td>
<td>6.2 ± 2.4</td>
<td>6.4 ± 1.8</td>
<td>0.970</td>
</tr>
<tr>
<td>Screening IOP, mmHg</td>
<td>16.8 ± 3.2</td>
<td>14.8 ± 3.0</td>
<td>0.826</td>
</tr>
<tr>
<td>Vertical cup/disc ratio</td>
<td>0.6 ± 0.2</td>
<td>0.5 ± 0.1</td>
<td>0.019</td>
</tr>
<tr>
<td>Spherical equivalence, Diopters</td>
<td>−0.3 ± 1.8</td>
<td>−0.2 ± 1.6</td>
<td>0.721</td>
</tr>
<tr>
<td>Axial length, mm</td>
<td>23.6 ± 1.1</td>
<td>23.4 ± 1.0</td>
<td>0.103</td>
</tr>
<tr>
<td>Central corneal thickness, μm</td>
<td>530.9 ± 22.2</td>
<td>533.0 ± 23.6</td>
<td>0.246</td>
</tr>
<tr>
<td>Disc size, mm²</td>
<td>2.4 ± 0.4</td>
<td>2.2 ± 0.4</td>
<td>0.034</td>
</tr>
<tr>
<td>Corneal Curvatures, mm</td>
<td>7.7 ± 0.3</td>
<td>7.7 ± 0.3</td>
<td>0.747</td>
</tr>
</tbody>
</table>
• Data are given as mean ± SD.

Fig 2 : Frequency of peak IOP occurring at different time points. Herein we counted all time points of peak IOP as the total number of peak IOP (n = 72).

Discussion
The two population based studies from India where glaucoma was diagnosed based on the International Society for Geographic and Epidemiological Ophthalmology are the Chennai Glaucoma Study and the West Bengal Glaucoma Study.

In the Chennai Glaucoma Study \(^6\), the
Mean IOP in normal subjects : 14.29 +/- 3.32 mm of Hg and
Mean IOP in PAOG : 17.93 +/- 5.35 mm of Hg

In the West Bengal Glaucoma Study \(^7\)
Mean IOP Right eye 13.8
Mean IOP Left eye 13.7

More than 80% of patients with POAG identified in a population-based prevalence survey from rural China had a peak IOP less than or equal to 21 mm Hg when IOP was measured during a 24-hour period. The peak IOP occurred during regular office hours in two-thirds of the patients with POAG, and both the mean IOP and fluctuation in IOP were similar in glaucoma eyes and contralateral nonglaucoma eyes in patients with unilateral glaucoma.

The present study adds further evidence that there is no obvious cutoff of IOP where glaucoma begins. Over 90% of subjects from Handan Study \(^8\) had IOP below the cutoff of 21 mm Hg and even 80% after a full 24-hour assessment; four out of five had IOP in the “normal” range. A recent study conducted in white subjects reported that the rate of progression of visual field loss in persons with glaucoma at lower IOP was slower than in those with higher IOP, \(^9\) and the prevalence of juxtafoveal defect seems to be more common in those with lower IOP. \(^10\) While there may be differences in the manifestation
of glaucoma in those with higher and lower IOP, there is no clear cutoff, and the
dependence on the number 21 is not justified as documented in this study. IOP appears to
be an inadequate screening tool in this population.
In conclusion, we demonstrated that the majority of persons with POAG had an IOP < 21
mm Hg in a population-based study of rural persons in the Gangetic West Bengal, India,
and observed that IOP in the glaucomatous eye was similar to the IOP in the contralateral
nonglaucomatous eye in unilateral cases. Factors other than IOP are likely play an
important role in the development of glaucomatous neuropathy.

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