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Intraocular Pressure Asymmetry in a Population Tested with the Pulsair Non-Contact Tonometer

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Summary

Intraocular pressure asymmetry as measured by noncontact tonometry (NCT) was analysed in a population of 874 individuals aged over 50 years. In both males and females the intraocular pressure (IOP) measured in the right eye exceeded that of the left.

Pressure asymmetry followed a normal distribution in a population subgroup known to have normal fields, discs and pressures. The 95% confidence intervals for the equation R IOP − L IOP in normals were 0.63 + or − 5.46 mmHg when the mean of four pulses per eye were used to calculate the IOP, increasing to 0.80 + or −6.56 mmHg for two pulses per eye (thus expanding the limits by 20%). The range of asymmetry for NCT in normals therefore exceeds that reported for Goldmann applanation tonometry.

Asymmetry was greater in females than males. Knowledge of the normal range of IOP asymmetry in each sex will help glaucoma screeners using NCT in their decision as to when to refer. A minimum of four pulses per eye should be used to assess the IOP when screening.

Glaucomatous subjects frequently demonstrate a greater severity of damage in the eye recording the higher intraocular pressure (IOP) at diagnosis.[1] IOP asymmetry, as measured by Goldmann applanation tonometry, rarely exceeds 4 mmHg in normal individuals.[2] Most optometrists who screen for glaucoma measure IOP, the majority using non-contact tonometers (NCT) such as the 'American Optical' or the recently introduced Keeler 'Pulsair'.[3] Referral of suspects with IOP asymmetry as the sole suspicious finding occurs not infrequently in clinical practice.

This study demonstrates the IOP asymmetry that can be expected when using the Pulsair to screen a population for IOP related disease.

Materials and Methods

This study uses IOP data derived from an epidemiological project that has been the subject of a number of previous reports.[4–7] 88.5% of eligible persons aged 50 years and over from a general practice population were screened for glaucoma using a protocol described in detail elsewhere.[4] All 874 persons (group A) had IOP assessment of both eyes by a single operator using the Pulsair NCT. IOP was recorded as the mean of four consecutive readings with the eye in the primary position, right eyes were always measured first.

A subpopulation comprising 741 of these individuals (group B) had IOPs <22 mmHg in both eyes, a normal Henson CFS2000 field examination, and normal optic discs as

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Table I *Mean (SD) IOPs in Group A (all subjects)*

	n	*Age (SD)*	*R Eye (SD)*	*L Eye (SD)*	*p(R>L)*
Males	374	63.9 (9.4)	15.33 (3.80)	14.85 (3.73)	0.04
Females	500	65.9 (10.2)	15.20 (3.68)	14.54 (3.30)	0.001

Table II *Mean (SD) IOPs in Group B (normals)*

	n	*Age (SD)*	*R Eye (SD*	*L Eye (SD)*	*p(R>L)*
Males	309	62.9 (8.6)	14.81 (3.08)	14.44 (3.19)	0.07
Females	432	64.9 (9.8)	14.88 (3.04)	14.07 (3.16)	<0.0001

assessed by an experienced observer 'blind' to IOP and field data. This latter group can therefore be considered a representative sample of the normal population aged 50 years and over.

p Values for comparing the group means were calculated using the two tailed 't' test.

Results

Table I shows the IOPs in group A by sex and the p values for asymmetry. Table II reports the equivalent results for group B.

There was no significant difference between the mean appointment times for males and females in either group A or B ($p = 0.65$ and 0.43 respectively), or in the mean IOP between the sexes. As would be expected in a sample known to be representative of the general population, the females were, however, older than the males ($p = 0.002$ for both groups).

Figures 1 and 2 demonstrate the frequency of IOP asymmetry recorded in group B when four and two pulses per eye are used. Both graphs show a normal distribution around the mean (0.63 mmHg R>L for four pulses per eye, 0.80 mmHg R> for two pulses per eye).

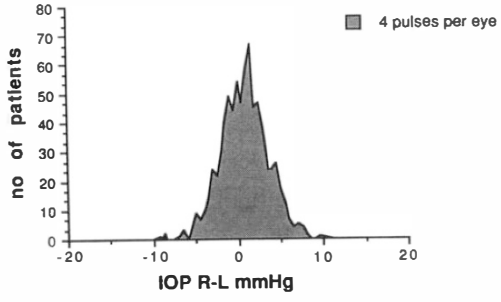

Fig. 1. *Frequency distribution of IOP asymmetry in normals (Group B) using the mean of 4 pulses per eye.*

The 95% confidence limits for the equation R IOP minus L IOP are shown in Table III for all normals and then for males and females separately. The effect of reducing the number of pulses per eye on the confidence intervals is also shown in the same table.

Discussion

To our knowledge this is the first report to indicate the IOP asymmetry to be expected when screening a population for glaucoma by NCT using the Keeler Pulsair. When the whole population is considered, IOP asymmetry reaches statistical significance in both males and females. Statistical significance is just lost in the group of normal males ($p=0.07$), but remains strong in the larger group of normal females indicating that is probably an effect of reducing the sample size.

NCTs sample the IOP during the ocular pulse[8] and a number of readings are therefore necessary to produce a valid result. The manufacturers of the Pulsair advise taking the mean of four consecutive readings as the IOP.

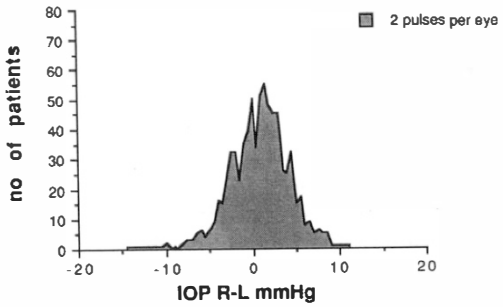

Fig. 2. *Frequency distribution of IOP asymmetry in normals (Group B) using the mean of 2 pulses per eye (See table 3 for means and 95% confidence intervals.)*

Table III *95% confidence limits for IOP asymmetrey in normals (RIOP–LIOP)*

	Pulses per eye	*Mean asym (mmHg)*	*95% confidence limits*	*Range (mmHg)*
All subjects	4	0.63	−4.84 to +6.09	10.93
	3	0.65	−5.23 to +6.52	11.75
	2	0.80	−5.77 to +7.37	13.14
Males	4	0.37	−5.05 to +5.80	10.85
	3	0.36	−5.42 to +6.15	11.35
	2	0.48	−6.31 to +7.27	13.58
Females	4	0.81	−4.66 to +6.28	10.94
	3	0.85	−5.07 to +6.77	11.84
	2	1.03	−5.34 to +7.40	12.74

Using this protocol, the Pulsair has been shown to correlate well with Goldman applanation[9–11] and we have recently reported the effect of altering the number of pulses per eye on the sensitivity and specificity of a screening programme.[7]

This study did not attempt to determine the variation in asymmetry that might occur in a normal population if the left eye, rather than the right, was measured first. This is because it is routine clinical practice to measure the right eye first and previous studies have conformed to this. Our findings are therefore relevant to current practice, in both screening and hospital clinic settings.

Two important findings from this study will be considered. Firstly, when screening a population at risk of glaucoma with a NCT, the IOP in the right eye has a statistically significant chance of being higher than the IOP in the left eye. Secondly, the frequency and degree of IOP asymmetry in normals, when using NCT, will be greater than when using Goldmann applanation tonometry. In addition, when only two pulses per eye are used to calculate the mean, the 95% confidence limits for IOP asymmetry are expanded by 16.6% in normal males and 25% in normal females (Table III).

Most epidemiological studies on IOP in a population have used applanation tonometry.[12–14] The Bedford study reported a high statistical probability that the IOP in the right eye would exceed that of the left ($p<0.0001$), whereas the Ferndale study found no degree of asymmetry. Both studies used a slitlamp based Goldmann tonometer and measured the right eye first, the former using the mean of three readings, the latter a single reading.

IOP recording with the Goldmann tonometer requires the operator to decide on an end point and read a scale, repeating the procedure for the fellow eye. The relative infrequency of certain IOP recordings in the Ferndale study indicates how operator bias may affect the measurement of IOP by this method.[15] In our study, no readings were rejected by the operator who is provided with a digital readout by the instrument. Operator bias is thus eliminated.

The only previous study to report on IOP asymmetry using NCT in a population used an American Optical instrument.[16] In this study, the upper of two consecutive measurements was taken if their difference was 2 mm or less. No significant IOP asymmetry was reported. All subjects were 'healthy employed people' and thus the population studied and the protocol for the assessment of IOP differed significantly from our study.

There are a number of reasons why the IOP in right eyes might tend to be higher in our study. Anxiety, by increasing muscle tone[17] or by inducing an inadvertent valsalva manoeuvre[18] might increase IOP and be expected to affect predominantly the first eye of a pair. An eccentric direction of gaze increases IOP,[19] and although every attempt was made to record IOP in the primary position, holding the Pulsair in the right hand may have induced a dextroversion when the right eye was tested in some subjects. Although considered unlikely, any 'machine decay' may cause the second four readings taken almost immediately after the first to underread slightly.

The intraocular pulse measured by continuous applanation has a mean amplitude of 2.8

(SD 1.2) mmHg in normals,[20] and varies with the cardiac and respiratory cycles. Although the diastolic pressure would be expected to be identical in the right and left eyes, the systolic may not because of the anatomic asymmetry of the thoracic major vessels. In a population where the ocular pulse is being sampled a number of times to produce a reading, this effect may be significant.

As would be expected in a population of normal individuals, the IOP asymmetry pattern approximates to a normal distribution (Figs 1 and 2). The 95% confidence limits for 'normal' IOP asymmetry with Pulsair NCT can therefore be applied when screening (Table III).

We plan to perform further analysis on our data using the eight individual IOP measurements taken per patient. This will reveal information concerning the 'range' of IOP readings to be expected within a set and the characteristics of each 'cohort' of readings (eg 3rd pulses L eye) within a population compared with other cohorts.

This study further emphasises the importance of using at least four pulses per eye if a NCT is used as a screening tool in the detection of pressure induced disease. When the right eye is measured first, IOP asymmetry, as the sole abnormality, should not be considered significant unless there is a difference of 5 mmHg or more between the eyes with the left IOP higher or 6 mmHg with the right higher, especially if the suspect is female. It should be remembered, however, that approximately 5% of normals will show this phenomenon on a single occasion.

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Key words: Asymmetry, glaucoma, IOP, normals, screening.

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