SCIENTIFIC REPORT

Intraocular pressure variability in patients who reached target intraocular pressure

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Aim: To assess the intraocular pressure (IOP) variability in patients with primary open angle glaucoma (POAG) under clinical treatment who reached an established target pressure based on isolated office readings.

Methods: Retrospective analysis of 65 eyes from 65 POAG patients under clinical therapy who submitted to modified diurnal tension curve (mDTC) (measurements at every 3 hours between 8 am and 5 pm) followed by a water drinking test (WDT). All subjects had established target IOP ⩽15 mm Hg at 11 am or 2 pm. IOP variability during mDTC or WDT was evaluated.

Results: mDTC revealed IOP measurements ⩾17 mm Hg in 16 of 65 eyes (24.6%). Nine eyes (13.8%) presented values ⩾18 mm Hg. The highest IOP detected by mDTC was 20 mm Hg in one patient (1.5%). WDT demonstrated IOP values ⩾17 mm Hg in 32 of 65 eyes (49.2%). 22 eyes (33.8%) presented values ⩾18 mm Hg after water ingestion. Moreover, IOP levels ⩾20 mm Hg were observed in 14 eyes (21.5%).

Conclusion: A great percentage of POAG patients undergoing clinical treatment and with IOP control based on single office measurement present significantly higher IOP measurements when performing mDTC and, especially, the WDT.

Elevated intraocular pressure (IOP) is considered the main risk factor for the development of glaucomatous damage. Glaucoma treatment is based mainly on IOP reduction to a level at which no additional damage is expected to occur. This level, the so called target IOP, is established on an individual basis and is usually assessed by single office measurements during working hours.

The benefits of IOP lowering have already been demonstrated by previous studies.[1 2] However, a significant group of patients still develop glaucomatous progression despite IOP values considered within adequate limits.[3–6] This could be explained by IOP fluctuation during the day or be the result of pressure peaks not detected during office examinations.[7–10]

IOP fluctuation is considered a risk factor for the progression of glaucoma.[7 8] Drance[9] demonstrated that almost one third of patients with single IOP measurements at office hours had pressure peaks only detected during a 24 hour pressure curve. Thus, monitoring the IOP at times during 24 hours of the day could be considered the best way to assess the IOP profile of glaucomatous patients.

In spite of its importance, a 24 hour diurnal tension curve (DTC) is not always feasible in the routine practice. Alternatively, a modified diurnal tension curve (mDTC) has become a common practice and consists of four to five IOP measurements during office hours (from 8 am to 6 pm). However, this test may miss as much as 70% of IOP peaks as a result of IOP variability and also because up to 70% of the highest IOP levels occur at 6 am in supine position.[11]

Another possible way to assess the IOP is the water drinking test (WDT). Besides being a practical way to estimate the pressure peaks through the 24 hours of the day,[12–16] the response to this test was also considered a risk factor for the development of glaucomatous visual field progression in open angle glaucoma.[15 16]

In this study, we assess the IOP variability using the mDTC and the WDT in patients with primary open angle glaucoma (POAG) undergoing clinical treatment who were considered to be well controlled with IOP equal to or under an established target pressure based on isolated office readings.

METHODS

In this retrospective study, we reviewed the charts of 65 POAG patients who submitted to a modified diurnal tension curve (measurements every 3 hours from 8 am to 5 pm) followed by the WDT from the private office of one of the authors (RSJ).

WDT consisted of basal IOP reading followed by ingestion of 1 litre of tap water. IOP was measured afterwards three times at 15 minute intervals.

All subjects had an established target IOP level of 15 mm Hg, based on glaucomatous damage level. One eye of each patient was randomly chosen for analysis. All eyes had to present IOP equal to or under 15 mm Hg at a single office reading at 11 am or 2 pm. IOP peaks were evaluated with mDTC and WDT.

RESULTS

In all, 65 eyes of 65 patients were included in this study; 29 (44.6%) patients were male. The mean age of all participants was 65.26 (SD 11.15, range 41–87) years.

Table 1 and figure 1 summarise IOP peaks detected by mDTC and WDT and their frequencies. mDTC revealed IOP measurements ⩾17 mm Hg in 16 of 65 eyes (24.6%). Nine eyes (13.8%) presented values ⩾18 mm Hg. The highest IOP detected by mDTC was 20 mm Hg in one patient (1.5%).

WDT demonstrated IOP values ⩾17 mm Hg in 32 of 65 eyes (49.2%). Twenty two eyes (33.8%) presented values ⩾18 mm Hg after water ingestion. Moreover, IOP levels of ⩾20 mm Hg were observed in 14 eyes (21.5%).

DISCUSSION

Despite IOP reduction obtained with glaucoma treatment, even when pressure levels are apparently well controlled, some patients continue to develop glaucomatous progression.[3–6] One possible explanation could be the occurrence of IOP peaks not detected during routine examination, as demonstrated by Drance,[9] who found that almost one third of patients with single IOP measurements taken at office

Abbreviations: mDTC, modified diurnal tension curve; POAG, primary open angle glaucoma; WDT, water drinking test

Table 1 Frequency of IOP peaks detected by mDTC and WDT

Maximum IOP detected (mm Hg)	Verified by mDTC		Verified by WDT	
	No of patients	%	No of patients	%
9	0	0.0	1	1.5
10	1	1.5	0	0.0
11	2	3.1	2	3.1
12	2	3.1	4	6.2
13	6	9.2	5	7.7
14	8	12.3	8	12.3
15	20	30.8	7	10.8
16	10	15.4	6	9.2
17	7	10.8	10	15.4
18	7	10.8	4	6.2
19	1	1.5	4	6.2
20	1	1.5	9	13.8
21	0	0.0	3	4.6
22	0	0.0	0	0.0
23	0	0.0	0	0.0
24	0	0.0	2	3.1

hours had pressure peaks only detected by a 24 hour tension curve. A study from Zeimer *et al*[11] showed that 29% of patients with progressive visual field damage presented IOP peaks in comparison to 5% of patients with stable visual fields. Also, the occurrence of IOP peaks was related to visual field loss progression in comparison with patients with stable visual fields in a study from Martinez-Belló *et al*,[17] which also did not demonstrate any significant difference between mean IOP levels of patients who developed progression in comparison to stable ones. These studies support the importance of detecting IOP peaks in glaucoma treatment.

A 24 hour daily tension curve would be a candidate for such task. However, this is a time consuming test associated with structural difficulties and costs as major drawbacks. Thus, other practical methods to detect pressure peaks and to assess fluctuation are needed.

The water drinking test was first described in the 1960s as a diagnostic test for glaucoma. After water ingestion, a 6 mm Hg or 8 mm Hg rise in IOP was considered a positive test for the diagnosis of glaucoma.[14] However, this test presented unacceptable false positive and false negative results.[18]

On the other hand, the WDT presents a good correlation between IOP peaks after water overload and IOP peaks detected during a daily tension curve.[14] Also, the importance of this test was demonstrated by Armaly *et al.*[16] In a prospective study of 5000 patients with open angle glaucoma, these authors studied 26 potential risk factors for the development of glaucomatous visual field lesion. From these, only five were considered significant: outflow facility, age, IOP, cup/disc ratio and change in IOP after water ingestion. Moreover, Yoshikawa *et al*[18] demonstrated that WDT was the main predictive test for glaucomatous progression in a group of patients with normal tension glaucoma.

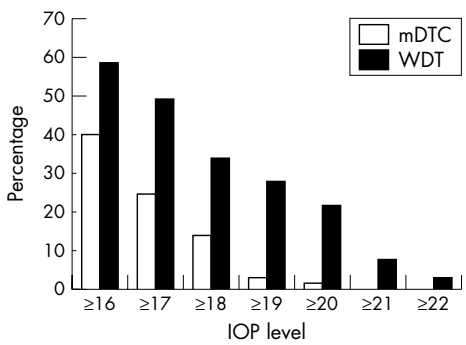

Figure 1 Frequency of IOP peaks detected by modified diurnal tension curve (mDTC) and water drinking test (WDT) (cumulative frequencies).

It has been hypothesised that the WDT could be used as an indirect tool to measure outflow facility. Indeed, Susanna and Medeiros,[19] using this test, were able to demonstrate reduced IOP fluctuation in patients controlled with filtering surgery in comparison with those controlled with topical medication.

All these data have changed the concept of the WDT, which is not used as a diagnostic test anymore, but as a useful tool to assess IOP peaks and IOP fluctuation.

In this study the IOP profile of POAG patients undergoing clinical treatment and apparently well controlled, as verified by single office measurements was assessed. This was done with a modified daily tension curve, widely used in general clinical practice, followed by the WDT. Both tests were capable of demonstrating the existence of IOP peaks. However, the frequency of detected peaks was higher when assessed by the WDT, which also demonstrated higher levels of IOP and higher fluctuation.

One explanation for this difference could be the fact that the modified daily tension curve does not measure the IOP during the times when it is expected to be higher (for example, 6 am) which, in turn, could be a result of the supine position of the patient at the time of measurement. Indeed, Hirooka and Shiraga[20] found a significant difference between IOP levels measured in the sitting and supine positions, the greater differences being in eyes with worse visual field damage. It is worth noting that their results suggested that more glaucomatous damage could happen during sleep in the supine position.

On the other hand, assuming that the WDT has a good correlation with the IOP peaks detected during a 24 hour daily tension curve, it is reasonable to accept that these high IOP levels are actually occurring through the day, presenting a considerable risk for the progression of the disease and which were revealed by this promising test. Moreover, this is an easy test to perform, involving the natural and physiological act of drinking water.

In summary, our data demonstrate the importance of a careful assessment of IOP profile in glaucomatous patients, even when clinical treatment seems to be adequate. The modified daily tension curve can demonstrate IOP peaks, although with lower frequency and lower amplitude in comparison with the water drinking test. This study also

emphasises the value that the water drinking test may have as a complementary test in clinical practice.

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ECHO

Long sight reduces learning in young schoolchildren

Please visit the *British Journal of Ophthalmology* website [www.bjophthalmol.com] for a link to the full text of this article.

Children are failing educationally because long sight is not seen as a problem, say doctors in South Wales who have studied more than a thousand schoolchildren.

Scores for national tests—proficiency in reading and writing English and progress in the national curriculum in English, mathematics, and science—were significantly lower for the children who had been referred to an optometrist and were the most long sighted (>+3D for both eyes or ⩾1.25 for best eye) than for those who were less affected (⩽+3D) and for those who had not been referred. Thirteen per cent of the total cohort had been referred to an optometrist after failing a test for long sight, and half of them needed glasses or a referral to an educational psychologist, or both. Many of those referred to the psychologist scored poorly in the tests.

The local community paediatric service screened almost 1300 children aged 8 years with a standard vision screening protocol changed to include a fogging test for long sight. Children failing this test or others were referred to an optometrist for treatment and possible further referral to an educational psychologist. Educational test results were obtained for consenting children.

This study tested the extent to which long sight is undiagnosed in young schoolchildren and confirmed its detrimental effect on learning. There is widespread dissent on vision screening standards and methods; screening for long sight is not performed in most schools; and the effectiveness of present preschool screening services has been questioned.

▲ Williams WR, *et al*. *Archives of Disease in Childhood* 2005;**90**:150–153.