SCIENTIFIC REPORT

Effect of a tight necktie on intraocular pressure

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Aim: To evaluate the effect of a tight necktie on intraocular pressure (IOP) measurement using Goldmann applanation tonometry.
Methods: 40 eyes of 20 normal subjects and 20 open angle glaucoma patients (all male) were enrolled. IOP was measured with an open shirt collar, 3 minutes after placing a tight necktie, and 3 minutes after loosening it. All measurements were made by the same examiner.
Results: Mean IOP in normal subjects increased by 2.6 (SD 3.9) mm Hg (p=0.008, paired *t* test; range –3 to +14 mm Hg) and in glaucoma patients by 1.0 (1.8) mm Hg (p=0.02, paired *t* test; range –2 to +4.5 mm Hg). In normal subjects, IOP in 12 eyes was increased by ≥2 mm Hg and in seven eyes by ≥4 mm Hg. In glaucoma patients, IOP in six eyes was increased by ≥2 mm Hg and in two eyes by ≥4 mm Hg.
Conclusion: A tight necktie increases IOP in both normal subjects and glaucoma patients and could affect the diagnosis and management of glaucoma.

Elevated intraocular pressure (IOP) remains the most important known risk factor for the development and progression of glaucomatous damage.[1] Accurate measurement of IOP remains crucial in decisions regarding management. Many patients wear tight neckties throughout the day and continue wearing them during IOP measurements. We hypothesised that this may elevate IOP by increasing episcleral venous pressure. During routine examination, if a patient were to be wearing a tight necktie, the increased IOP could lead to an erroneous diagnosis of ocular hypertension or even glaucoma.

Moreover, if the patient consistently were to wear a tight necktie as a normal preference in daily life, this could lead to a sustained increase in IOP and could predispose to the development of glaucomatous optic neuropathy, thereby rendering a tight necktie a risk factor as well as a confounder of accurate IOP measurement. We evaluated the effect of tight neckties on IOP measurement by Goldmann applanation tonometry.

METHODS

Normal subjects and open angle glaucoma patients were enrolled in this prospective study. Informed consent was obtained from each subject using a consent form approved by the institutional review board for human research of the New York Eye and Ear Infirmary. All subjects were male, had best corrected visual acuity of 20/60 or better, and wore collared shirts. Subjects were excluded if they had current infection or inflammation in either eye, any abnormality preventing reliable applanation tonometry in either eye, strabismus, previous incisional glaucoma filtration surgery, or other non-glaucomatous disease affecting the visual field.

All normal subjects had IOP ≤21 mm Hg by Goldmann applanation tonometry, normal optic disc appearance based upon clinical examination, and normal achromatic automated perimetry. Normal optic disc appearance was defined as vertical cup to disc asymmetry ≤0.2, cup/disc ratio ≤0.6, and an intact neuroretinal rim without peripapillary haemorrhages, notches, localised pallor, or nerve fibre layer defect. Achromatic automated perimetry indices showed a mean defect (MD) and corrected pattern standard deviation (CPSD) within 95% confidence limits and a glaucoma hemifield test result within normal limits. Glaucoma patients had glaucomatous optic nerve damage and associated repeatable achromatic visual field loss in the corresponding hemifield location. Glaucomatous optic neuropathy was defined as cup/disc asymmetry between the eyes of >0.2, rim thinning, notching, excavation, or nerve fibre layer defect.

Subjects were seated comfortably in an examination chair at all times. One drop of Fluorocaine (Medical Ophthalmics, Inc, Tarpon Springs, FL, USA; fluorescein sodium 0.25%, and oxybuprocaine (proparacaine) 0.5%) was instilled in each eye before tonometry. IOP was measured in primary gaze by the same masked examiner for each patient and recorded by an independent reader. Two consecutive IOP readings in each eye were taken with an open shirt collar. The necktie was tightened around the buttoned collar to the point of slight discomfort and IOP remeasured after 3 minutes. The tie and collar were then loosened and IOP remeasured 3 minutes later. If the subject had a tight collar when entering the office, he was told to loosen the collar for at least 5 minutes before commencement of the study. To prevent the examiner from knowing the pressure measurements, the tonometer was reset to 5 mm Hg after each IOP measurement.

Statistical analyses were performed using JMP software (SAS Institute, Inc, Cary, NC, USA). The IOP measurements were subjected to paired *t* tests. A p value of less than 0.05 was considered statistically significant.

RESULTS

Twenty eyes of 20 normal subjects and 20 eyes of 20 open angle glaucoma patients were enrolled. Normal subjects were younger than the glaucoma patients (mean age 35.1 (SD 9.6) (range 21–57 years) *v* 62.2 (11.4) years (range 42–75 years), p<0.0001). Table 1 shows IOP before, during, and after necktie tightening. Mean IOP in normal subjects increased by 2.6 (3.9) mm Hg (p=0.008, paired *t* test) and in glaucoma patients by 1.0 (1.8) mm Hg (p=0.02) following tightening. After loosening the tie, mean IOP in normal subjects decreased by 3.3 (2.7) (p<0.0001) and in glaucoma patients by 1.3 (2.1) (p=0.02). There was no difference in IOP before necktie tightening and after loosening in both normal subjects and glaucoma patients (mean change +0.7 (2.1) mm Hg (p=0.16); and +0.25 (1.4) mm Hg (p=0.44), respectively). The increase in IOP after tightening was not related to age (r^2=0.08, p=0.23 for normal subjects; r^2=0.007, p=0.73 for glaucoma patients). There was no difference in IOP elevation between glaucoma patients and normal subjects during necktie tightening (p=0.38, *t* test), nor in IOP decrease after necktie loosening (p=0.26). In normal subjects, IOP of 12 eyes increased by ≥2 mm Hg and in seven eyes by ≥4 mm Hg. In glaucoma patients, IOP of six eyes increased by ≥2 mm Hg and in two eyes by ≥4 mm Hg. IOP changes by group, before, during and after necktie tightening, are shown in Table 2.

Table 1 Goldmann applanation tonometry mean IOP (SD) (range) measurements before, during necktie tightening, and after loosening the necktie

	Normal (n=20)	Glaucoma (n=20)
Mean IOP before tightening (mm Hg) (range)	15.3 (2.6) (10 to 20)	16.9 (3.8) (12.5 to 25)
Mean IOP during tightening (mm Hg) (range)	17.9 (3.9) (12 to 26)	17.9 (4.9) (12 to 29)
Mean IOP after loosening (mm Hg) (range)	14.6 (2.1) (9.5 to 18)	16.6 (4.2) (11 to 27.5)
Mean IOP difference (before and during tightening) (mm Hg) (range)	2.6 (3.9) (–3 to +14)	1.0 (1.8) (–2 to +4.5)
p Value (paired *t* test)	0.008	0.02
Mean IOP difference (during tightening and after loosening) (mm Hg) (range)	3.3 (2.7) (–10 to +0.50)	1.3 (2.1) (–8.5 to +1)
p Value (paired *t* test)	<0.0001	0.02
Mean IOP difference (before tightening and after loosening) (mm Hg) (range)	0.7 (2.1) (–4 to +4)	0.25 (1.4) (–4 to +2.5)
p Value (paired *t* test)	0.16	0.44

Table 2 IOP changes before, during necktie tightening, and after loosening the necktie

	Decreased	Increased	No change
Normal (n=20)			
Before tightening to during tightening (mean IOP change, mm Hg)	4 (20%) (1.6)	14 (70%) (4.1)	2 (10%)
During tightening to after loosening (mean IOP change, mm Hg)	18 (90%) (3.7)	1 (5%) (0.5)	1 (5%)
Before tightening to after loosening (mean IOP change, mm Hg)	11 (55%) (2.3)	7 (35%) (1.6)	2 (10)
Glaucoma (n=20)			
Before tightening to during tightening (mean IOP change, mm Hg)	6 (30%) (0.9)	12 (60%) (2.1)	2 (10%)
During tightening to after loosening (mean IOP change, mm Hg)	12 (60%) (2.3)	4 (20%) (0.8)	4 (20%)
Before tightening to after loosening (mean IOP change, mm Hg)	10 (50%) (1.3)	7 (35) (1.1)	3 (15%)

DISCUSSION

Accurate measurement of IOP is important for the detection and management of glaucoma. Numerous situations and factors that can lead to erroneous and inaccurate IOP readings include instrumental, anatomical, physiological, examiner induced and patient induced sources of error.[2–10]

In an earlier study, inflation of a sphygmomanometer cuff around the neck to 40 mm Hg conferred a doubling of IOP.[11] This demonstrated that an extremely tight constriction around the neck would cause an increase in IOP. In using a necktie instead of a blood pressure cuff, and having our patients subjectively determine their point of discomfort, we approximated a real life situation and demonstrated a common and often overlooked risk factor for increased IOP and a confounder for accurate IOP measurement. A tight necktie can be considered a risk factor in men who prefer to wear tight neckties, men with thick necks, and white collar professionals. In our study, although the mean IOP was not greatly increased after tightening the necktie, 70% of normal patients and 60% of glaucoma patients experienced an increase in IOP and there were clinically significant individual results both in normal subjects and glaucoma patients.

In addition, the tight necktie is a confounder of accurate IOP measurement. If the patient has a tight necktie while getting his IOP checked, this can lead to an inadvertent diagnosis of ocular hypertension or misinterpretation of a risk for disease progression by an inexperienced clinician. The pressure increase is indeed real, but would not have been present had the patient not had the constriction around his neck.

We hypothesise that the mechanism for the increased IOP is that the tight necktie constricts the jugular vein, thereby causing elevated venous pressure and thus elevated episcleral venous pressure, in turn elevating IOP.[12] In this study, the 3 minute time intervals were chosen as an estimation of the time it takes to physiologically respond to the tightening and loosening. Therefore, whether or not autoregulation would have brought the pressure down if we had left the necktie on for a little longer or whether the data would differ if the time intervals were different remains to be determined. Moreover, a follow up study using Perkins applanation tonometer and Tonopen when the patients were resting comfortably would answer the question of whether the act of leaning forward with a tight necktie for Goldmann applanation tonometer further raises IOP.

There was no difference in IOP elevation between glaucoma patients and normal subjects during necktie tightening in this study. Whether the fact that the glaucoma patients were on various IOP lowering medications might have affected the results can be the subject of further investigation. Not all subjects experienced an increase in pressure after tightening, and some even had a decrease. This unexpected result might be attributable to anatomical variation and possibly a baroreceptor reflex. Normal deviation from the mean must also be taken into account.

In summary, a tight necktie may cause an increase in IOP in susceptible individuals and should be included among the confounders of accurate IOP measurement and considered as a risk factor for increased IOP.

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