ORIGINAL ARTICLE

Changes in intraocular pressure after pharmacological pupil dilatation in an elderly Chinese population in Taiwan: The Shihpai eye study

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Abstract

Background: Mydriatic drugs are often used in ophthalmic clinics for pupil dilatation to assess the optic nerve and retina. Clinical studies have indicated that an increase in intraocular pressure (IOP) after pupil dilation is noted in open-angle glaucoma patients, those with narrow angles and in normal subjects. Asians are more likely to have narrow angles. Moreover, age-related cataract may increase the crowdedness of the angle. This study aimed to assess the effects of mydriatic pupil dilatation on IOP in an elderly Chinese population.

Methods: The Shihpai Eye Study was a community-based, cross-sectional survey of vision and eye diseases among noninstitutionalized subjects aged 65 years and older in Shihpai, Taipei, Taiwan. IOP was taken using noncontact tonometry. The pupil was dilated with 1% tropicamide. IOP was measured again after maximal pupil dilatation 1 hour after mydriasis.

Results: Of the 2045 participants, 1361 (66.6%) participated in both the questionnaire and eye examinations. The mean IOP before pupil dilatation was 12.9±3.1 mmHg and was 12.8±3.4 mmHg (range: 5-36 mmHg) after pupil dilatation. IOP higher than 21 mmHg after pupil dilation was noted in 17 (1.34%) participants, of whom IOP exceeded 30 mmHg in two (0.16%). Overall, the changes in IOP before and after pupil dilatation were insignificant ($p = 0.04$). In the final regression analyses, refractive status toward hyperopia ($p < 0.01$) was the only significant factor associated with an increase in IOP of at least 4 mmHg after pupil dilatation.

Conclusion: Our results revealed that the increase in IOP after pharmacological pupil dilatation was minimal, and the incidence of acute angle-closure attack was insignificant. Hyperopic status was the only factor related to an increase in IOP of > 4 mmHg. Caution should be exercised if one is hyperopic or has a history of glaucoma and rechecking IOP in these subjects is suggested after pharmacological mydriasis.

Keywords: Chinese; Elderly; Intraocular pressure; Mydriatic drugs; Pupil dilatation

1. INTRODUCTION

Intraocular pressure (IOP) is a major risk factor of glaucoma. It is also the only modifiable risk factor. In the general population, IOP has been shown to be associated with age, sex, race, iris color, cornea thickness, hypertension, diabetes, obesity, smoking, alcohol consumption, exercise, and spherical equivalent.[1–5]

Mydriatic drugs are often used in ophthalmic clinics for pupil dilatation to assess the optic nerve and retina. Clinical studies have indicated that an increase in IOP after pupil dilation is noted in open-angle glaucoma patients,[6,7] those with narrow angles,[8,9] and in normal subjects too.[10] However, only a few population-based studies have investigated the effect of pharmacological pupil dilatation on IOP in the elderly population and assessed the associated factors. Asians are more likely to have narrow angles.[11] Moreover, age-related cataract which is common in the elderly may increase the crowdedness of the angle. Hence, it is a concern that pupil dilatation may predispose the elderly to develop acute angle closure attack or impose a significant increase in IOP. This study aimed to assess the effects of mydriatic pupil dilatation on IOP in an elderly Chinese population.

2. METHODS

The Shihpai Eye Study was a community-based,[12–14] cross-sectional survey of vision and eye diseases among noninstitutionalized subjects aged 65 years and older in Shihpai, Taipei, Taiwan. Residents aged 65 years and older were identified using the household registration system. The household registration system in Taiwan is designed and administered by the government to collect and supply demographic information and to officially recognize the personal status and relations for efficient

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city planning and competent socioeconomic developmental programs. According to the official household registration in 1999, the total number of residents aged 65 years and older in Shihpai was 4750; 3746 persons were eligible, and 2045 of these were randomly selected to be invited to participate in the study.[13] Of the 2045 subjects, 1361 (66.6%) participated in both the questionnaire and eye examination. The baseline examination was conducted between July 1, 1999, and December 31, 2000. A structured questionnaire was used to obtain baseline information on demographic data (age, gender, locality, marital status, and education), personal medical history (diabetes mellitus, hypertension, and cardiovascular disease as well as glaucoma, previously diagnosed by a physician), family history, and lifestyle (smoking and alcohol intake). Subjects that were interviewed were invited to participate in a comprehensive ophthalmic examination in Taipei Veterans General Hospital. Ophthalmologists conducted the examinations according to a standardized protocol. Informed consent was obtained from each subject after explaining the purpose and procedure of the study. The survey followed the tenets of the Declaration of Helsinki. This study was approved by the Institutional Review Board of the Taipei Veterans General Hospital (VGHIRB 89-11-01A).

2.1. Definitions

IOP was taken using noncontact tonometry (CT-60 NCT; Topcon Corporation, Tokyo, Japan). The IOP measurements were performed in both eyes, and the mean value of three successive measurements was accepted as the final result. The pupil was dilated with 1% tropicamide (Alcon, Couvreur, Puurs, Belgium) twice with a 10-minute interval for lens grading at the slit-lamp and indirect ophthalmoscopy. IOP was measured again after maximal pupil dilatation 1 hour after mydriasis and was confirmed by research assistant using a penlight. Lens condition was assessed by slit-lamp and graded into three principal types of opacity (nuclear sclerosis, cortical opacity, and posterior subcapsular opacity) according to the Lens Opacities Classification System III (LOCS III).[15] The refractive error was measured with autorefraction and expressed as a spherical equivalent.

Height and weight were measured in metric units and were recorded to the nearest one-tenth kilogram for weight and the nearest one-tenth centimeter for height. A mercury sphygmomanometer was used to measure blood pressure. Three consecutive blood pressure readings, separated by at least 5-minute intervals, were obtained from both arms, with participants in a seated position. The higher mean value in either arm was used in the analysis. Oxygen saturation was measured using a pulse oximeter (model 3301; BCI Inc, Waukesha, WI), which displays fractional oxygen saturation. Smoking and alcohol behaviors were categorized as current, former, or never. Daily water intake volume was divided into five categories, ranging from less than 1000 mL in the lowest group to more than 4000 mL in the highest group.

2.2. Statistical analysis

Means and standard deviation of IOP were calculated. Univariate analysis of IOP with independent variables was first detected by the *t* test for continuous variables and Chi-square analysis for categorical variables. Multivariate analysis was then used to fit the best model after adjusting for confounding factors. A *p* value of <0.05 was considered to be statistically significant.

We were also interested in whether systemic or ocular factors were associated with an increase in IOP of 4 mmHg or more after pupil dilatation. The same statistical procedure used for evaluating IOP after pupil dilation was used for this analysis. Statistical analysis was performed using commercial software (SAS 6.12; SAS Institute, Cary, NC).

3. RESULTS

Of the 2045 participants, 1361 (66.6%) participated in both the questionnaire and eye examinations. Six hundred seventy-seven (33.1%) subjects cooperated only for the household interview. Seven (0.03%) participants could not be contacted despite three home visits.

IOP data could be obtained for 1355 (99.6%) participants who were examined. After pupil dilation, IOP was available for 1265 (92.9%) participants. Sixty-three people (4.6%) were excluded from the analysis because they had a history of glaucoma or had been treated for this condition with medication, surgery, or both. Those who were pseudophakic were also eliminated from the analysis of the association of IOP with refractive error and nuclear opacity. Because there was a strong correlation between the mean IOP of both eyes ($r = 0.77$, $p < 0.001$), only data for the right eye are presented.

Fig. 1 shows the distribution of the IOP after pupil dilatation, which was slightly skewed to the right. The mean IOP after pupil dilatation was 12.8 ± 3.4mmHg (range: 5-36 mmHg) for the entire study population. The mean IOP before pupil dilatation was 12.9 ± 3.1 mmHg. IOP higher than 21 mmHg after pupil dilation was noted in 17 (1.34%) participants, of whom IOP exceeded 30 mmHg in two (0.16%). Overall, the changes in IOP before and after pupil dilatation were insignificant ($p = 0.04$). Fifty-two (4.1%) participants experienced an IOP increase of ≧4 mmHg; among them, an increase in IOP of at least 8 mmHg was observed in two (0.16%).

IOP after pupil dilatation was associated with female sex ($p = 0.04$), higher systolic blood pressure ($p < 0.0001$), history of alcohol consumption ($p < 0.01$), and hyperopic refractive status ($p = 0.04$) (Table 1). We were also interested in the factors contributing to a significant increase in IOP of 4 mmHg or more after pupil dilatation. In the final regression analyses controlling for all covariates, refractive status towards hyperopia ($p < 0.01$) was the only significant factor associated with an increase in IOP of at least 4 mmHg after pupil dilatation (Table 2).

4. DISCUSSION

Mydriatics is commonly used in clinical practice for pupil dilatation to assess the fundus. However, there has been concern that pupil dilatation may precipitate acute angle closure in individuals with narrow angles.[8,9] It has been documented that pupil dilatation may cause an increase in IOP in primary open-angle glaucoma patients,[6,7] the increase being correlated to the likelihood of future progression of glaucoma.[7] This phenomenon is equally observed even in those with normal angles.[10] Hence, previous studies have highlighted the importance of rechecking IOP after pharmacological pupil dilatation.

Considering the higher prevalence of glaucoma among the elderly, our objective was to evaluate the distribution of IOP after pupil dilatation and assess whether this is related to personal, medical, or lifestyle factors in an elderly Chinese population in Taiwan.

Our results revealed that the increase in IOP after pharmacological pupil dilatation was minimal, and the incidence of acute angle-closure attack was insignificant. Hyperopic status was the only factor related to an increase in IOP of >4 mmHg. It has been reported that compared to the distribution of IOP before pupil dilatation, the curve is slightly shifted toward the right.[16] Factors associated with IOP before and after pupil dilatation (female, an increase in systolic blood pressure, history of previous alcohol drinking) were almost identical. We further noticed that the hyperopic status was related to IOP after pupil dilatation.

Our results are in concordance with Hancox, who recruited 270 patients from glaucoma, retina, and cataract services. The

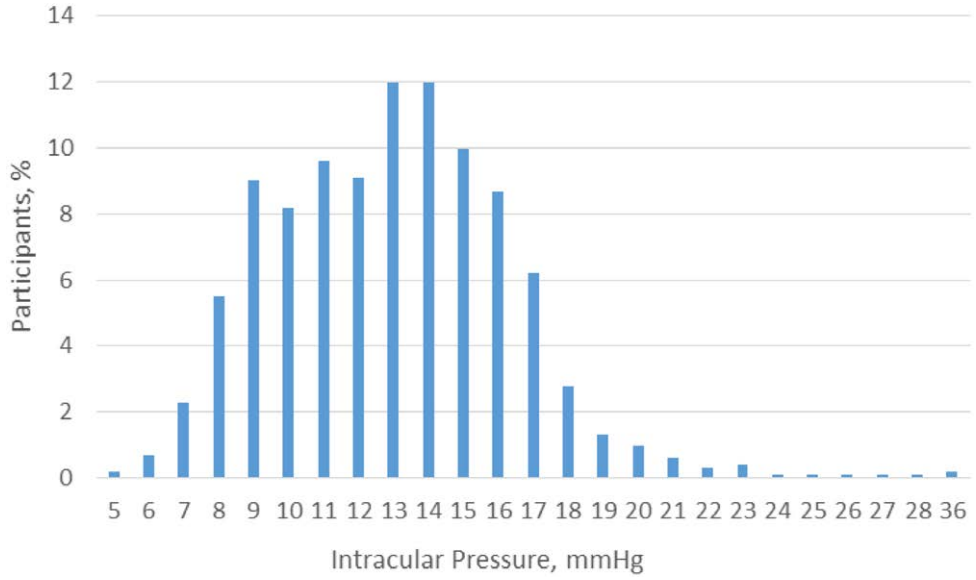

Fig. 1 Distribution of intraocular pressure after pupil dilatation in Shihpai, Taipei, Taiwan.

author showed an overall mean change of 0.4 mmHg, 45 minutes after administration of cyclopentolate. A maximum of 5% of the observations might have been expected to exceed ±2 mmHg (4.1% of participants exceeded 4 mmHg in our study). In their study, logistic regression adjusted for age, sex, diagnosis, ethnicity, ocular medication, iris color, and lens status as risk factors for an increase in IOP of ≥5 mmHg did not reveal any significant contribution. On the other hand, Kim et al[10] included 32 patients with a mean age of 61.7 years and normal open angles and observed a significant increase in IOP (a mean of 1.85 mmHg) after dilatation.

The mean predilatation and postdilatation IOP were 11.48 ± 2.85 mmHg and 12.36 ± 2.58 mmHg, respectively. Although a statistically significant increase in IOP was noted, its clinical relevance requires further evaluation.

In a study conducted by Shaw and Lewis,[6] a significant pressure elevation (>5 mmHg) occurred in 37 eyes (32%) in open-angle glaucoma patients with a marked pressure elevation (>10 mmHg) occurring in 14 eyes (12%). This is in contrast to the study by Lavanya et al[8] who evaluated 471 Asian primary angle closure suspects and noted that the risk of acute angle closure within 12 hours of pupil dilatation was 0.64% after receiving oral acetazolamide prophylaxis. Approximately 1% of patients developed an IOP increase of more than 8 mmHg after 1 hour in either eye. They concluded that there was a low risk of acute angle closure after pupil dilatation in subjects with a shallow anterior chamber or occludable angle. Similarly, Wang et al[9] noticed that postdilatation IOP elevation is similar among primary angle closure suspect (PACS) patients receiving laser peripheral iridotomy in one eye and the untreated contralateral eye. The risk of developing acute angle-closure is very low among patients with PACS. This study implied that routine laser peripheral iridotomy before pupil dilatation is not recommended in patients with PACS. Our study is in agreement with the above two findings that pupil dilatation induces an insignificant increase in IOP in the general elderly population. However, caution should be exercised if one is hyperopic, and rechecking IOP in these subjects is suggested after pharmacological mydriasis. It should also be noted that participants analyzed in this study were restricted to those without a history of glaucoma. The risk of IOP change in primary angle closure glaucoma, which may be unknown to the elderly, is much higher after pupil dilatation, and IOP follow-up is always advised in susceptible cases. It is also interesting to note that the association between IOP and lifestyle factors such as smoking, alcohol consumption, and daily water consumption is debatable. In the present study, a positive association between alcohol intake ($p < 0.01$) and IOP after pupil dilatation was noted following multivariate analysis. However, this does not contribute to an increase in IOP of >4 mmHg as shown in Table 2. In contrast, smoking and drinking water intake were not significantly associated with IOP after pupil dilatation.

Our study had some limitations. First, potential participants who were institutionalized were not examined. Excluding inpatients, the paralyzed and disabled may have accounted for a disproportionate number of people with physical and/or visual impairment and excluding them from the participant pool may have biased our results.

Table 1

Multivariate analysis of intraocular pressure after pupil dilatation in Shihpai, Taipei, Taiwan

Independent variable	Standardized coefficient	*p*
Gender: female	0.538	0.0396
Age (increase)	–0.033	0.1586
Systolic blood pressure, mmHg (increase)	0.033	<0.0001
Diastolic blood pressure, mmHg (increase)	0.006	0.6267
Pulse rate (increase)	0.008	0.3645
Oxygen saturation (increase)	0.018	0.7952
Alcohol drinking (yes)	0.884	0.0075
Smoking (yes)	0.063	0.8015
Daily water drinking (increase)[a]	0.258	0.0686
BMI (increase)	0.052	0.1070
Nuclear opacity grade(increase)[b]	0.049	0.8051
Refractive status (increase)[c]	0.094	0.0379

BMI = body mass index.

[a]Daily water drinking: 1: <1000 mL, 2: 1000 to 2000 mL, 3: 2001 to 3000 mL, 4: 3001 to 4000 mL, 5: >4000 mL.

[b]Nuclear opacity grade: 1: nuclear opacity grade 1-2; 2: nuclear opacity grade 3-4, 3: nuclear opacity grade 5-6.

[c]Refractive status = spherical equivalent; sphere power + 1/2 cylinder power.

Table 2

Multivariate analysis of post dilation increase in intraocular pressure of at least 4 mmHg in Shihpai, Taipei, Taiwan

Independent variable	Odds ratio (95% CI)	*p*
Gender: female	0.795 (0.608-1.039)	0.0930
Age (increase)	1.022 (0.997-1.047)	0.0866
Systolic blood pressure, mmHg (increase)	1.000 (0.992-1.008)	0.9863
Diastolic blood pressure, mmHg (increase)	1.005 (0.992-1.018)	0.4960
Pulse rate (increase)	1.002 (0.993-1.011)	0.6936
Oxygen saturation (increase)	0.998 (0.929-1.072)	0.9611
Alcohol drinking (yes)	1.102 (0.786-1.546)	0.5740
Smoking (yes)	0.838 (0.646-1.088)	0.1850
Daily water drinking (increase)[a]	1.119 (0.967-1.294)	0.1300
BMI (increase)	1.003 (0.971-1.037)	0.8430
Nuclear opacity grade (increase)[b]	0.932 (0.758-1.146)	0.5071
Refractive statue (increase)[c]	1.065 (1.016-1.115)	0.0085

BMI = body mass index.

[a]Daily water drinking: 1: <1000 mL, 2: 1000 to 2000 mL, 3: 2001 to 3000 mL, 4: 3001 to 4000 mL, 5: >4000 mL.

[b]Nuclear opacity grade: 1: nuclear opacity grade 1-2, 2: nuclear opacity grade 3-4, 3: nuclear opacity grade 5-6.

[c]Refractive status = spherical equivalent; sphere power + 1/2 cylinder power.

Nevertheless, our study had several strengths. This is one of the few community-based studies on the ophthalmic condition of older adults in Asia. Clinical examinations were performed by professionally trained ophthalmologists at a well-equipped medical center.

Our results revealed that although elderly Asians are more prone to have a narrow angle, no participant developed an acute angle closure attack in this survey. However, it should be noted that a hyperopic status is associated with an increase in IOP after pupil dilatation and rechecking of IOP is advised. Mydriatic pupil dilatation is generally safe in elderly Asian populations.

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REFERENCES

1. Weih LM, Mukesh BN, McCarty CA, Taylor HR. Association of demographic, familial, medical, and ocular factors with intraocular pressure. *Arch Ophthalmol* 2001;**119**:875–80.
2. Wu SY, Leske MC. Associations with intraocular pressure in the Barbados Eye Study. *Arch Ophthalmol*1997;**115**:1572–6.
3. Klein BE, Klein R, Linton KL. Intraocular pressure in an American community. The Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci*1992;**33**:2224–8.
4. Foster PJ, Machin D, Wong TY, Ng TP, Kirwan JF, Johnson GJ, et al. Determinants of intraocular pressure and its association with glaucomatous optic neuropathy in Chinese Singaporeans: the Tanjong Pagar study. *Invest Ophthalmol Vis Sci* 2003;**44**:3885–91.
5. Lee JS, Lee SH, Oum BS, Chung JS, Cho BM, Hong JW. Relationship between intraocular pressure and systemic health parameters in a Korean population. *Clin Exp Ophthalmol*. 2002;**30**:237–41.
6. Shaw BR, Lewis RA. Intraocular pressure elevation after pupillary dilation in open angle glaucoma. *Arch Ophthalmol*.1986;**104**:1185–8.
7. Siam GA, de Barros DS, Gheith ME, Da Silva RS, Lankaranian D, Tittler EH, et al. The amount of intraocular pressure rise during pharmacological pupillary dilatation is an indicator of the likelihood of future progression of glaucoma. *Br J Ophthalmol* 2007;**91**:1170–2.
8. Lavanya R, Baskaran M, Kumar RS, Wong HT, Chew PT, Foster PJ, et al. Risk of acute angle closure and changes in intraocular pressure after pupillary dilation in Asian subjects with narrow angles. *Ophthalmology* 2012;**119**:474–80.
9. Wang L, Huang W, Han X, Liao C, Jin L, He M. The impact of pharmacological dilation on intraocular pressure in primary angle closure suspects. *Am J Ophthalmol* 2022;**235**:120–30.
10. Kim JM, Park KH, Han SY, Kim KS, Kim DM, Kim TW, et al. Changes in intraocular pressure after pharmacologic pupil dilation. *BMC Ophthalmol* 2012;**12**:53.
11. He M, Foster PJ, Johnson GJ, Khaw PT. Angle-closure glaucoma in East Asian and European people. Different diseases? *Eye (Lond)* 2006;**20**:3–12.
12. Tsai SY, Hsu WM, Cheng CY, Liu JH, Chou P. Epidemiologic study of age-related cataracts among an elderly Chinese population in Shih-Pai, Taiwan. *Ophthalmology* 2003;**110**:1089–95.
13. Cheng CY, Hsu WM, Liu JH, Tsai SY, Chou P. Refractive errors in an elderly Chinese population in Taiwan: the Shihpai eye study. *Invest Ophthalmol Vis Sci* 2003;**44**:4630–8.
14. Kuang TM, Tsai SY, Hsu WM, Cheng CY, Liu JH, Chou P. Body mass index and age-related cataract: the Shihpai eye study. *Arch Ophthalmol* 2005;**123**:1109–14.
15. Chylack LT Jr, Wolfe JK, Singer DM, Leske MC, Bullimore MA, Bailey IL, et al. The lens opacities classification system III. The longitudinal study of cataract study group. *Arch Ophthalmol* 1993;**111**:831–6.
16. Lin HY, Hsu WM, Chou P, Liu CJ, Chou JC, Tsai SY, et al. Intraocular pressure measured with a noncontact tonometer in an elderly Chinese population: the Shihpai eye study. *Arch Ophthalmol* 2005;**123**:381–6.