Singapore Med J 1999; Vol 40(10):644-647

Screening for Glaucoma in the Chinese Elderly Population in Singapore

D H J Sim, L G Goh

ABSTRACT

Aim: To determine the performance of different tests in screening for glaucoma.

Method: The results from a glaucoma prevalence study of 479 Chinese elderly Singaporeans were analysed. Glaucoma screening tests evaluated in this study included Goldmann applanation tonometry (GAT), non-contact tonometry (NCT), optic disc assessment, screening Humphrey visual field and gonioscopy. The sensitivity, specificity and positive predictive values of the various screening tests in detecting glaucoma were calculated.

Results: The sensitivity of GAT and NCT at a specificity of at least 90% was 26% and 30% respectively with a low positive predictive value (PPV) of 0.13. Optic disc assessment with a vertical cup-disc ratio cut-off of more than 0.7 had a sensitivity of 100% and a specificity of 94% and a PPV of 0.46. The sensitivity of visual fields was 100% with a specificity of 76% and a PPV of 0.17. Gonioscopy had a sensitivity of 100% and specificity of 93% and a PPV of 0.14 in detecting primary angle closure glaucoma.

Conclusion: Optic nerve assessment performed better than other glaucoma screening tests. There are, however, many other considerations that need to be taken into account in determining the ideal test for population screening.

Keywords: screening, epidemiology, glaucoma, population, prevalence, elderly

1 Kim Seng Promenade
#01-38A Great World City
Singapore 237994

D H J Sim, MMed (Ophth), FRCS (Ed), FRCOphth (UK), FAMS
Consultant Ophthalmologist

Department of Community, Occupational and Family Medicine
National University of Singapore
Lower Kent Ridge Road
Singapore 119074

L G Goh, MBBS, MMed (Int Med), MRCGP
Associate Professor

Correspondence to:
Dr D H J Sim

Singapore National Eye Centre
11 Third Hospital Ave
Singapore 168751

INTRODUCTION

Screening for glaucoma has long been desirable, but the issue of implementing a public screening programme has not been without controversy. On one hand, the nature of glaucoma fulfils all the criteria for screening. It has a high prevalence and high-risk groups can easily be identified. It is a major cause of blindness with the large majority of those with glaucoma remaining undiagnosed and unaware of it. Glaucoma treatment can effectively prevent blindness in the majority, particularly if detected early. On the other hand, the diagnosis of glaucoma can be complex because the clinical parameters used in diagnosing glaucoma overlap between glaucoma and normal individuals. One must also recognise the fundamentally different approach towards glaucoma diagnosis in the clinic setting and in population screening. The diagnosis of glaucoma by an ophthalmologist in a clinic setting is based on history, intraocular pressure measurement, optic disc examination, perimetry, gonioscopy and slit lamp examination. Such a protocol is geared towards early detection of glaucoma but would be too costly and time-consuming for mass screening. A single test or combination of tests must be identified to justify screening en masse. The objective of mass screening would be to detect only the moderate to advanced cases and not all cases so as to reduce the burden of false positives that might potentially overwhelm the healthcare system.

The senior citizen study[1] analysed the prevalence of glaucoma in a randomly selected elderly Chinese population in Singapore (n = 479). This study allows us to evaluate the performance and suitability of various glaucoma tests for mass screening.

MATERIALS AND METHODS

The senior citizen study was conducted between 1991 and 1994 as a joint study between ophthalmologists from the Department of Ophthalmology at Tan Tock Seng Hospital and the Singapore Home Nursing Foundation.

The study population was a cross-sectional random sample survey of the Chinese elderly aged 60 and older residing in Singapore. A sampling frame of 3,000 names was obtained from the database of the Ministry of Home Affairs based on the 1990 population census. From this multiracial sampling frame, the Chinese population was selected as the study population. The selected elderly were invited by letters to attend the eye screening sessions at Hougang Senior Citizens Health Care Centre.

Details of the eye screening examinations have been published and a summary is included here. The eye screening examinations were conducted over two visits. On the first visit, the respondent was seen by a trained nurse or trained therapy aide. Non-contact tonometry (NCT) was performed with the Topcon air-puff tonometer (CT-20) to measure the intraocular pressure (IOP). The average of three readings was recorded for each eye. Humphrey automated perimetry (Humphrey Field

Analyser I) was performed using the central 80 point screening test with the threshold-related strategy. Retinal fundus photography was performed with the Topcon TRC-NW3 non-mydriatic camera with the image (45 degree field) captured on Polaroid film.

The second visit comprised an eye examination by an ophthalmologist from the Department of Ophthalmology, Tan Tock Seng Hospital. Slit lamp examination and Goldmann applanation tonometry (GAT) was performed. Gonioscopy with a Goldmann 2 mirror contact lens was also performed and angle findings were graded from 0 to 4 using Becker-Shaffer's classification[2]. Fundus and disc examinations were performed through a dilated pupil by indirect ophthalmoscopy with a 20 dioptre lens. This was supplemented when necessary with indirect slit lamp examination with a 90 dioptre lens or the Goldmann contact lenses. The optic discs were examined and cup-disc ratios were assessed.

All fundus photographs were reviewed and the vertical cup-disc ratios of the optic discs were assessed by one reviewer. Only photographs with sufficient clarity of the optic nerve and distinct cup and disc margins were included in this assessment. The initial clinical cup-disc ratio assessments by the examining ophthalmologists were used in the analysis except in cases where there was a discrepancy with the photographic ratio assessment of at least 0.2. In these cases, the photographic ratio was used instead if the disc photographs permitted a confident assessment. As non-stereoscopic fundus polaroid photographs were used, cup pallor was used as a guide, but disc vessel kinking at the cup margin was the primary criterion for determining the cup margin[3]. All photographs of discs with vertical cup-disc ratios equal or greater than 0.8 were assessed twice.

All Humphrey visual fields were reviewed and classified as glaucomatous, non-glaucomatous or indeterminable eg. when there was coincident significant retinal pathology. A field was considered glaucomatous if there was a significant scotoma in an arcuate or nasal step pattern or in Bjerrum's area. A significant scotoma was defined as one consisting of at least 3 confluent test points. The most superior 4 test points and the most inferior 2 test points of the test pattern were not considered as defects as these points had a higher probability of being artifactual. If significant parapapillary chorioretinal degeneration was detected on the fundus photos, the ring of test points immediately adjacent to the blind spot were also excluded. As the threshold related strategy was used, any defect on the visual field would be at least 6 dB below threshold.

An angle was classified as occludable when at least 3 quadrants were graded Shaffer grade 1 or narrower[4]. Primary angle closure glaucoma (PACG) was diagnosed if the eye had occludable angles, a cup-disc ratio of 0.8 or greater and a glaucomatous visual field.

Primary open angle glaucoma (POAG) was diagnosed if the cup-to-disc ratio was 0.8 or greater with a glaucomatous visual field, non-occludable angles and an intraocular pressure greater than 21 mmHg. Normal tension glaucoma (NTG) was diagnosed if the cup-to-disc ratio was 0.8 or greater with a glaucomatous visual field, non-occludable angles and the intraocular pressure was 21 mmHg or less. Only Goldmann applanation tonometry readings were used for diagnostic classification. Individuals diagnosed with glaucoma or glaucoma suspects were advised and referred for further evaluation and treatment at their preferred centre.

Sensitivity, specificity and positive predictive values were calculated for NCT, GAT and optic disc assessment at different cut-off values. Sensitivity, specificity and positive predictive values (PPV) were also calculate for the Humphrey central 80 point screening test as well as for gonioscopy, specifically in relation to screening for PACG.

RESULTS

Four hundred and seventy nine Chinese elderly responded to the invitation for an eye examination, giving a response rate of 23.8 %. Of these, 53 were advised to go for further evaluation because of confirmed or suspected glaucoma. Only 22 (42%) were subsequently referred as the others declined further evaluation. The majority were referred to government restructured hospitals. A search through government restructured hospital records showed that 17 (32%) elderly had gone for further evaluation.

Based on the diagnostic criteria adopted, 23 cases of glaucoma were identified giving a prevalence of 4.8%. Of these, 14 (61%) had NTG, 3 (13%) had POAG and 6 (26%) had PACG.

GAT and NCT were assessed at the cut-off pressures of $>$ 20 mmHg to $>$ 22 mmHg. At the traditional cut-off value of $>$ 21 mmHg, the sensitivity and specificity for GAT was 22% and 93% respectively with a PPV of 0.13. For NCT at a cut-off value of $>$ 22 mmHg, the sensitivity was 30%, specificity was 90% and the PPV was 0.13. The test results are summarised in Table I.

Optic disc assessment with a vertical cup-disc ratio cut-off at $>$ 0.7 gave a sensitivity of 100% and specificity of 94% and a PPV of 0.46. An abnormal screening Humphrey visual field gave a sensitivity of 100% and specificity of 76% with a PPV of 0.17. Forty-two (9% prevalence) elderly were classified to have an occludable angle and of this, 6 were diagnosed with PACG. In screening for PACG, gonioscopy had a sensitivity of 100%, a specificity of 92% and a PPV of 0.14. The test results are summarised in Table I.

DISCUSSION

Glaucoma is a leading cause of world blindness. It is estimated that by the year 2000, there will be 66.8 million with glaucoma worldwide, with 6.7 million bilaterally blind from glaucoma[5]. The World Health Organisation[6] estimates that East Asia may

Table I – Summary of performance of glaucoma screening tests

Screening criterion	Sensitivity (%)	Specificity (%)	Positive predictive value
GAT IOP > 20 mmHg	26	91	0.13
GAT IOP > 21 mmHg	22	93	0.13
NCT IOP > 21 mmHg	35	84	0.1
NCT IOP > 22 mmHg	30	90	0.13
Optic disc assessment (CD ratio > 0.6)	100	80	0.2
Optic disc assessment (CD ratio > 0.7)	100	94	0.46
Abnormal screening HVF	100	76	0.17
Gonioscopy	100 *	92 *	0.14 *

* Values shown are only for primary angle closure glaucoma.

contribute to 50% of the glaucoma blind in the world. Blindness from glaucoma is irreversible but largely preventable if detected early. Yet the large majority of people with glaucoma are unaware they have it with 50%[7] to 90%[8] remaining undetected. Amongst the elderly in Singapore, 97%[1] are undiagnosed and it is precisely the fast growing elderly population that is at higher risk of developing glaucoma. Public education is vital as glaucoma awareness is lacking. Glaucoma screening is also the only way to detect this silent condition at an earlier stage.

In this study, tonometric screening by GAT and NCT has sensitivity values at 26% and 30% with a specificity around 90%. The PPV is 0.13 giving a high false positive rate of 87%. This result supports other previous studies that have highlighted the limitations of tonometric screening[9,10]. However, elevated intraocular pressure still remains the most important risk factor for glaucoma[7]. Non-contact tonometry is also fast, portable and easily performed by a trained technician with the potential of detecting up to 30% of glaucomas. The identification of false positives (ocular hypertensives) by tonometry also serves a role as it identifies individuals who are at higher risk of developing glaucoma and should be followed-up.

The vertical cup-disc ratio at a cut-off of 0.8 had a high level of sensitivity and specificity. It should be noted however that the sensitivity is artificially high. This is because the performance of a screening test is also dependent on the definition used in diagnosing the condition. In this study, a cup-disc ratio of 0.8 or greater was necessary for the diagnosis of glaucoma. In reality, glaucoma can and does occur at cup-disc ratios significantly less than 0.8. Optic disc photography for glaucoma screening is feasible but it can be costly and requires trained and experienced personnel for accurate interpretation. Photography is also limited by media opacities such as cataracts which would be prevalent amongst the elderly. Stereo disc photography was not used in this study but has been shown to be superior[11,12] but would require pupil dilation for satisfactory stereo separation. The issue of determining a satisfactory cut-off cup disc ratio for a balance of sensitivity and specificity also arises. Newer methods of optic disc imaging and analysis are available and are being evaluated but their current cost is prohibitive.

Visual fields have been advocated as a screening test because it has performed better than tonometry and optic disc evaluation[13]. The results from this study however indicate a less than satisfactory specificity of 76% with the field criteria adopted. Visual field testing is traditionally costly, non-mobile and time-consuming. Field results are also not always accurate as it is influenced by the learning curve and patient reliability. This is particularly so amongst the elderly. Definite field loss on perimetry is nonetheless a sensitive indicator of significant glaucoma. Newer, cheaper and faster perimetry machines are being evaluated for mass screening and preliminary results are encouraging.

Gonioscopy was excellent in detecting all cases of PACG. However, the PPV was poor at 0.14 and the presence of occludable angles is therefore not necessarily a good predictor of the development of PACG. Gonioscopic evaluation can however yield more information if a more detailed angle grading system was used and indentation gonioscopy was performed. Gonioscopy is more invasive than other screening tests and requires an experienced ophthalmologist. A simpler method of angle screening using the van Herick method might prove to be an acceptable screening alternative. The importance of early detection of PACG should be remembered because it is potentially curable in the early stages with a simple and safe laser procedure. Late detection when it has progressed to chronic glaucoma would necessitate life-long treatment with medication or surgery.

Some of the major limitations in this study include the limited response rate (23.7%) to the primary screening examination and the response of glaucoma suspects to referrals (32%) for further specialist evaluation and confirmation of diagnosis. The limited referral rate meant that the diagnosis of glaucoma in the majority of cases was based on the clinical findings obtained during the screening examination as few had gone for further specialist assessment. These were some of the reasons why some of the diagnostic criteria adopted in this study were more stringent, so as to err on the side of underestimating rather than overestimating the prevalence of glaucoma. The limited referral rate together with the glaucoma definitions adopted in this study, also explain why some screening tests such as cup-disc ratio and perimetry had artificially high sensitivities. The fact that the response rate to both the primary screening examination and the secondary referral were poor, despite being advised of possible ocular pathology, is evidence of the attitudes and lack of awareness amongst our elderly. It is also a reflection of the silent nature of glaucoma and how patients are often not aware of their visual deficit until it is advanced.

The Ministry of Health guidelines[14] on screening state that the aim of screening for diseases that cause

visual impairment is to correct the defect or prevent its occurrence and the disease must be important and fairly common with a detectable pre-symptomatic stage. Early treatment of the disease should also be more effective than treatment applied after symptoms have appeared. Glaucoma fulfils these requirements. The guidelines also stipulate that for screening, a safe and reproducible test must be available at a reasonable cost. The test should have a high sensitivity and a high specificity to reduce false negative and positive rates. The test should also be fast and easily administered by a trained technician. A high level of sensitivity in screening for glaucoma is costly and time-consuming as it requires a comprehensive history, examination and investigations by highly trained personnel. Sensitivity and specificity are inversely related and it is difficult to find a single test with both excellent sensitivity and specificity. In the absence of an ideal screening test, the focus of mass screening should be slanted towards a higher specificity with some sacrifice in sensitivity so as to reduce the burden of false positives. Some ethical considerations do arise when sensitivity is compromised, but these can be countered to some extent by physician awareness of the limitations and public education. It is such issues that have stifled the development of an accepted public-funded glaucoma screening programme in most countries and left the lead to private and voluntary organisations to provide some form of public screening. Unfortunately, due to a lack of clear guidelines on glaucoma screening, there is often no uniformity in diagnostic equipment or referral criteria.

In assessing the cost-effectiveness and feasibility of screening, one should also consider the context of the local health setting. The primary healthcare network in Singapore in the form of the government outpatient services is very accessible and caters to a very large segment of the target population. These outpatient polyclinics also already have an eye screening programme and team in the form of the diabetic eye screening programme that rotates between polyclinics. The cost of implementing a glaucoma screening programme in the Singapore context would therefore be relatively lower and more cost-effective because of the existing infrastructure and machinery.

CONCLUSION

The approach to preventing glaucoma blindness in the aging population in Singapore should comprise public education and screening. Mass screening is still a controversial issue because there is at present, no ideal single test or combination of tests for glaucoma screening. It is clear however that glaucoma causes significant blindness and is prevalent amongst the elderly with the majority of cases remaining undiagnosed. Screening is therefore desirable and screening guidelines need to be established to prevent increasing blindness. We should also be mindful of the unique primary healthcare situation in Singapore where the system and infrastructure already in place would easily accommodate a glaucoma screening programme.

REFERENCES

1. Sim DHJ, Goh LG, Ho T. Glaucoma pattern amongst the Chinese elderly in Singapore. Ann Acad Med Singapore 1998; 27:819-23.
2. Kolker AE, Hetherington. Clinical interpretation of gonioscopic findings. In: Becker-Shaffer, editor. Diagnosis and Therapy of the Glaucomas. 3rd ed. St Louis, Mosby; 1970:41-50.
3. Schwartz B. Cupping and pallor of the optic disc. Arch Ophthalmol 1973; 89:278-86.
4. Arkell SM, Lightman DA, Sommer A, Tyler HR, Korshim OM, Tielsch JM. The prevalence of glaucoma among Eskimos of Northwest Alaska. Arch Ophthalmol 1987; 105:482-5.
5. Quigley HA. Number of people with glaucoma worldwide. Br J Ophthalmol 1996; 80(5):389-93.
6. Thylefors B, Negrel AD, Parajasegaram R, Dadzie KY. Global data on blindness. Bull World Health Organisation 1995; 73(Pt 1):115-21.
7. Sommer A, Tielsch JM, Katz J, Quigley HA, Gottsch JD, Javitt J, Singh K. Relationship between intraocular pressure and primary open angle glaucoma among white and black Americans: the Baltimore Eye Survey. Arch Ophthalmol 1991; 109:1090-95.
8. Klein BEK, Klein R, Sponsel WE, Franke T, Cantor LB, Martone J, et al. Prevalence of glaucoma: the Beaver Dam Eye Study. Ophthalmology 1992; 99 (Pt 10):1499-504.
9. Shields MB. The challenge of screening for glaucoma. Am J Ophthalmol 1995; 120:793-5.
10. Tielsch JM, Katz H, Singh K, Quigley HA, Gottsch JD, Javitt J, et al. A population-based evaluation of glaucoma screening: the Baltimore eye survey. Am J Epidem 1991; 134:1102-10.
11. Lichter PR. Variability of expert observers in evaluating the optic disc. Trans Am Ophthalmol Soc 1976; 74:532-72.
12. Varma R, Steinmann WC, Scott IU. Expert agreement in evaluating the optic disc for glaucoma. Ophthalmol 1992; 99:215-21.
13. Katz J, Tielsch JM, Quigley HA, Javitt J, Witt K, Sommer A. Automated suprathreshold screening for glaucoma: the Baltimore eye survey. Invest Ophthalmol Vis Sci 1993; 34:3271-77.
14. Kwa SB. Health screening. Singapore Medical Association Newsletter 1994; 25(7):14.