European Journal of Ophthalmology / Vol. 14 no. 1, 2004 / pp. 19-25

Glaucoma among Omani diabetic patients: a cross-sectional descriptive study

(Oman Diabetic Eye Study 2002)

R. KHANDEKAR[1], R. ZUTSHI[2]

[1]Eye Health Care, DSDC, DGHA, Ministry of Health
[2]Glaucoma Unit, Al Nahdhah Hospital, Muscat - Oman

PURPOSE/METHODS. *A cross-sectional study was carried out to review the ocular status of 2,063 diabetic patients in Oman. A part of this study is presented to highlight the magnitude and determinants of glaucoma. The study also recommends policies for comprehensive care of glaucoma among diabetic patients. The ocular pressure, disc changes, and field changes were noted by ophthalmologists. The diabetes profile was noted by physicians.*
RESULTS. *The rate of glaucoma among diabetic patients was 8.87% (95% CI 8.12 to 9.62). Male diabetic patients had significantly higher rates of glaucoma than female diabetic patients. The rate was significantly higher in higher age groups. The mean ocular pressure in glaucomatous eyes was 28.6 mm Hg. The rate was not significantly different in patients with type I and type II diabetes (RR 1.03 [95% CI 0.61 to 1.79]). The risk of visual disability was higher among diabetic patients with glaucoma than diabetic patients without glaucoma (RR 1.56 [95% CI 1.14 to 2.13]).*
CONCLUSIONS. *Ocular pressure measurement could be a simple and reliable first-level screening tool. Diabetic patients with glaucoma should be given special care to reduce visual disability. All patients with diabetes should be thoroughly checked periodically to rule out glaucoma. (Eur J Ophthalmol 2004; 14: 19-25)*

KEY WORDS. *Glaucoma, Diabetes, Oman, Visual disability*

Accepted: November 7, 2003

INTRODUCTION

Glaucoma is one of the leading causes of blindness in Oman. Ten percent of the blind population in Oman had glaucoma as the principal cause of the blindness (1). Estimation of the magnitude of glaucoma disease in a population is difficult (2). However, a national health program needs such information to plan prevention of blindness activities. Information on glaucoma among the high-risk population could help in determining priority intervention policies. Diabetic patients are at high risk for developing glaucoma (3, 4). However, limited information on the magnitude and determinants of glaucoma in diabetic patients, especially in Middle Eastern countries, is available.

The Sultanate of Oman is a country in the Middle Eastern peninsula with a population of nearly 2.4 million (mid-2001 projections). Rapid socioeconomic development has changed the lifestyle of the population in the last two decades. A marked decline in commu-

 1120-6721/019-07$15.00/0

nicable diseases and nutritional disorders has been reported. However, in presence of factors such as obesity, sedentary lifestyle, smoking, and consanguinity, the risk for noncommunicable diseases such as diabetes has increased (5). The prevalence of diabetes in people older than 20 years is 10%. Another 10% have impaired glucose tolerance (IGT) (6). The Ministry of Health, Oman, has promoted health for all and initiated a comprehensive primary health care approach to face these newer challenges. At nearly 140 primary health institutions, healthcare is provided free of charge and it is accessible to the needy even in remote places of Oman (7). A system of primary care by trained physicians was instituted in the 1990s to identify, register, and care for patients with diabetes. In 10 secondary level institutions, diabetologists assess diabetic patients annually. Since 1995, care of diabetic eye complications has been standardized. Nearly 85 ophthalmologists in 25 institutions provide care to the eye patients in nine health regions (5). The eye patients of Wousta region, which has a sparse nomadic population, are treated in the neighboring regions.

A study was conducted in 2002 to review the ocular profile of diabetic patients screened by ophthalmologists in Oman. The authors present part of this study, related to the magnitude of glaucoma and its determinants among diabetic patients. The study also aimed to propose comprehensive eye care policies for diabetic patients with glaucoma.

MATERIALS AND METHODS

Study design

This was a cross-sectional hospital-based descriptive study.

Study population

The 5,560 diabetic patients who had undergone eye screening were the study population. Diabetic patients who visited an eye department for an eye checkup were included in the study.

Sample size

To represent this population, by using nonclustering method, for a prevalence study, 1,200 subjects need to be randomly selected. This will achieve 90% power of the study and 95% confidence interval. It is assumed that 10% of diabetic patients have glaucoma and a study with this sample size should detect the rate between the range between 8% and 12%. To compensate for the clustering effect (as the cases would be selected from 24 ophthalmic units of nine regions) and loss of cases, the sample was multiplied by a factor of 1.8. The final minimum required sample was 2,160.

Sampling frame

The national sample was further stratified into nine regional subgroups. The regional proportions of diabetic patients screened were used as reference for subsampling. The diabetic patients examined for eye problems in each region were listed. To select the required sample from the list, random number table was used.

Study investigators

Twelve qualified ophthalmologists with more than 5 years of experience were the study investigators.

Definitions

The World Health Organization (WHO)–recommended levels of oral glucose tolerance test (OGTT) for determining diabetes were taken as reference to define diabetes. Distance vision and visual disabilities were recorded as per the International Classification of Diseases–10 codes. If ocular pressure was greater than or equal to 22 mm Hg and the cup-disc ratio was more than 0.6, the eye was labeled as having glaucoma. If pressure was more than 21 mm Hg and cup-disc ratio was less than 0.6, the eye was considered to have ocular hypertension. If ocular pressure was less than 21 mm Hg and cup-disc ratio was more than 0.6, the condition was defined as normal tension glaucoma. Standard field changes of glaucoma were taken as corroborative evidence to label an eye as having glaucoma.

Procedures

The attending physician/diabetologist examined the subjects to review the diabetes and comorbidity. They noted type, duration, blood sugar level, HbA1c level, and systemic comorbidity. After counseling, the physicians referred the cases to the ophthalmologist of the same or a nearby institution.

The qualified opticians tested visual status of each eye using Snellen distance vision chart. They recorded the visual status and disabilities as per WHO recom-

mended parameters. Presence of diabetic retinopathy, cataract, corneal opacities, and strabismus in each eye was also noted.

Ocular pressure was measured using applanation tonometer attached to the biomicroscope. At limited sites, indentation method of measuring ocular pressure was used. Disc and retinal changes suggestive of glaucoma, such as pallor of the neuroretinal rim, cup-disc ratio, over pass phenomenon, notching of blood vessel, splinter hemorrhage on and around disc, and nerve fiber layer defects, were noted. For detailed fundus examination, biomicroscope and +90 Volk lens were used. The picture of optic disc was drawn in the case file. The senior ophthalmologist of the unit reviewed the fundus findings and labeled the eye as glaucomatous, with ocular hypertension, or normal.

The retinal changes of diabetes were noted after dilating the pupil. Indirect binocular pan retinal ophthalmoscope was used for this purpose. If one eye had glaucoma, the person was considered to have glaucoma.

Field changes were noted using either Humphrey analyzer or Goldmann perimeter. Refractive error was adjusted at the time of the field testing. Experienced opticians conducted kinetic perimetry in subjects with clear central media. Field changes, such as arcuate scotoma, blind spots in Bjerrum area, peripheral field restriction, and presence of temporal island of field, were noted.

The duration of diabetes was graded as less than 5 years, 6 to 10 years, 11 to 15 years, and 16 or more years. This information was based on health records of first diagnosis of diabetes. The metabolic control of diabetes was determined by measuring HbA1c levels. If it was more than 9%, the metabolic control was considered inadequate.

Quality assurance procedures

A standardization workshop was held to explain definitions of ocular conditions, methodology of the eye screening, reporting, and management. The printed study protocol was distributed to the ophthalmologist. Standardized pretested data collection forms were used. The eye screening of diabetic patients was supervised by the head of the ophthalmology department and the study investigators carried out spot checks in the regions to ensure uniform methodology. The experienced epidemiologist and statistician assisted the investigators in analysis.

Data management

The data collection form was used to note personal details, profile of diabetes, and ocular status of each eye. The proposed treatment was also noted for each case. The forms were forwarded to the central data manager. The data were computed using EPI6. Statistical Package for Social Studies (SPSS 9) was used for analysis. A code book of variables was maintained. Univariate analysis method was used. Frequencies, percentage proportion, and mean ocular pressure were calculated. The 95% confidence interval (CI) was estimated for the statistical validation. While representing the rates for the study population, they were adjusted using indirect method of age sex standardization. The age and sex proportion of diabetic patients found in the Nizwa study in Oman (8) was taken as the reference for this exercise.

Ethical issues

Permission of local and national authorities was obtained for the study. The participants gave verbal consent to use the health information for the study. The confidentiality of the identity of the subjects was maintained by giving unique identification codes and files were accessible to the principal investigator only. The results of the study were used for improving eye care of diabetic patients in Oman. Patients with glaucoma and other ocular complications were treated free of charge. A seminar was held to distribute the results to the regional health staff.

Limitations

Oman is a trachoma endemic country and large proportions of the elderly population have trachoma sequel. Many of them are illiterate. Cases with trachomatous corneal opacities also limited the retinal examination and ocular pressure measurement. In addition, field changes may be inconsistent and may not be noted due to illiteracy of the older population or corneal scarring.

RESULTS

Representation and sample profile

Of the 2,160 randomly enumerated patients, 2,063 (95.5%) were examined. The profile of the study population and the examined sample is given in Table I. Age, sex, and regional distributions differed markedly.

TABLE I - CHARACTERISTICS OF THE EXAMINED SAMPLE (Oman Diabetic Eye Study 2002)

Characteristics	Diabetic patients		Examined sample	
Sex	**No.**	**%**	**No.**	**%**
Male	2,537	45.64	809	39.21
Female	3,021	54.36	1,254	60.79
Age group (83 missing), yr				
Less than 40	847	15.22	409	19.83
40 to 49	1,371	24.64	600	29.08
50 to 59	1,371	24.64	478	23.17
60 to 69	1,532	27.54	381	18.47
70+	444	7.97	112	5.43
Region				
Muscat	476	8.55	488	23.65
Dhofar	96	1.73	97	4.70
Dhakhiliya	773	13.89	238	11.54
North Sharqiya	959	17.24	147	7.13
South Sharqiya	340	6.11	179	8.68
North Batinah	1,870	33.61	342	16.58
South Batinah	475	8.54	219	10.62
Dhahira	301	5.41	287	13.91
Musundam	276	4.96	16	0.78
National				
		5,564		2,063

TABLE II - MAGNITUDE OF GLAUCOMA AND ITS DETERMINANTS (Oman Diabetic Eye Study 2002)

Epidemiologic variant	Frequency	%	Estimated cases	Adjusted rate*	95% CI
Sex					
Male	86	10.63	276	11.50	10.25 to 12.74
Female	82	6.54	167	7.18	6.26 to 8.10
Age group (112 missing), yr					
<40	12	2.93	18	2.93	1.80 to 4.07
40 to 49	41	6.83	68	7.50	6.11 to 8.89
50 to 59	53	11.09	147	11.51	9.82 to 13.20
60 to 69	44	11.55	166	13.12	11.43 to 14.81
70+	12	10.71	43	13.39	10.22 to 16.56
Region					
Muscat	53	10.86	56	11.07	8.25 to 13.88
Dhofar	7	7.22	6	7.22	2.04 to 12.39
Dhakhiliya	24	10.08	79	10.92	8.73 to 13.12
North Sharqiya	9	6.12	52	8.84	7.05 to 10.64
South Sharqiya	9	5.03	21	7.82	4.97 to 10.68
North Batinah	33	9.65	135	9.94	8.59 to 11.30
South Batinah	13	5.94	27	6.39	4.19 to 8.55
Dhahira	18	6.27	16	6.97	4.09 to 9.59
Musundam	2	12.50	34	12.50	8.60 to 16.40
National					
	168	8.14	443	8.87	8.12 to 9.62

* Rates are adjusted using indirect method of age sex standardization

Hence, standardized results could be more accurate.

Magnitude of glaucoma in diabetic patients

The rate of glaucoma in screened diabetic patients was 8.87% (95% CI 8.12 to 9.62). The frequencies, percentage proportion, projected numbers in the study population, adjusted rates, and 95% CI for glaucoma in diabetic patients and its variants are given in Table II. Male diabetic patients had significantly higher rates of glaucoma than female diabetic patients. In the higher age group, the rate of glaucoma among diabetic patients was high. South Batinah and Dhahira regions had low rates of glaucoma; Muscat and Dhakhiliya regions had high rates of glaucoma.

Ocular pressure by method

The mean ocular pressure per method is presented in Table III. Ocular pressure both by indentation and aplanation method was high in eyes with glaucoma and low in eyes without any glaucomatous optic disc changes. Eyes that had undergone surgical treatment for glaucoma in the past were excluded from the evaluation.

Glaucoma and type of diabetes

Of 183 patients with type I diabetes, 14 (7.7%) had glaucoma. Among 1,809 patients with type II diabetes, 143 (7.9%) had glaucoma (RR 1.03 [95% CI 0.61 to 1.79]).

Glaucoma and type of retinopathy

Of the 311 diabetic patients with retinopathy, 22 (7.1%) had glaucoma. Of the 1,579 cases without retinopathy, 123 (7.7%) had glaucoma. The information of 121 cases was missing (RR 1.09 [95% CI 0.7 to 1.7]).

Glaucoma and visual disability among diabetic patients

Of 168 diabetic patients with glaucoma, 20 (11.9%) were bilaterally blind, 33 (19.6%) had low vision, and

TABLE III - OCULAR PRESSURE BY METHOD (OMAN DIABETIC EYE STUDY 2002)

Eyes (n= 4,049)	By aplanation method		By indentation method		Total	
	no.	mean	no.	mean	no.	mean
(A) >22 mmHg	129	27.22	88	30.55	217	28.57
(B) 17 to 22 mmHg	1,062	18.73	830	18.25	1,892	18.52
(C) 10 and 16.9 mmHg	1,614	14.33	326	13.74	1,940	14.23

TABLE IV - GLAUCOMA BY DURATION AND METABOLIC CONTROL OF DIABETES

Diabetes variable	Diabetic patients with glaucoma	Diabetic patients without glaucoma	Statistical validation
Duration of diabetes, yr* (n=1,801)			
less than 5	99	1,285	-2 = 7.41
6 to 10	32	455	df =3
11 to 15	13	113	p=0.05
16+	10	58	
Metabolic control of diabetes (n=528)			
HbA1c < 9%	12	191	RR=1.46
HbA1c ≥ 9%	28	297	95% CI 0.75 to 2.80

112 (66.7%) were without visual disability. Of the 1,895 diabetic patients without glaucoma, 300 (15.8%) were bilaterally blind, 126 (6.6%) had low vision, and 1,468 (77.6%) were without visual disability (RR 1.56 [95% CI 1.14 to 2.13]).

Glaucoma and duration of diabetes

Longer duration of diabetes increased risk of glaucoma among diabetic patients (Tab. IV). This had marginal statistical significance.

Glaucoma and metabolic control of diabetes

Risk of glaucoma as comorbidity was marginally higher in subjects with inadequate metabolic control of diabetes (Tab. IV). However, the element of chance cannot be ruled out in this observation.

DISCUSSION

Because limited information was available on glaucoma among diabetic patients in Oman, this study could be useful in improving care of glaucoma among diabetic patients.

The examined sample had adequate coverage in relation to the diabetic patients who presented for eye screening. Those diabetic patients who presented for eye checkup could be more health conscious and thus could systematically differ from those who did not undergo eye examination. Therefore, results of the present study should be extrapolated to the registered diabetic patients in Oman with caution.

Ocular pressure was measured by applanation as well as indentation method. In cases of corneal opacities and high myopia, the ocular pressure measured with indentation method could differ from that measured by the applanation method. Because northern and central Oman are trachoma endemic zones, many cases of corneal opacities exist. Thus differential measurement bias could be introduced. Schoitz tonometry, a type of indentation tonometry, was found to be as useful as applanation tonometry in the present study. It was also considered a valid tool to screen for glaucoma (9).

Missing data related to age in around 5% of the sample are likely to be from the elderly population, which could introduce misclassification bias.

To minimize the confounding effects of age, sex, and

geographic area, indirect standardization method was used.

The glaucoma rate among Omani diabetic patients was 8.9% in the present study. It was 6% in Denmark (10), 7.8% in the United States (11), and 11% in Spain (9). It was as low as 1.1/1,000 population of diabetic patients in the United Kingdom (12) and 1.5/1,000 in Vienna (13). Thus the literature suggests a wide range of glaucoma rates among diabetic patients. The rate of diabetes among glaucoma cases was also found to be much higher in black patients (17.2%) compared to white patients (10.6%) (14). The Omani population includes subjects of Asian and African origins. Hence, the present study is likely to have higher rates of glaucoma among diabetic patients than among white diabetic patients. In addition, lack of field testing in the same subjects resulting in differential case definition also could cause difference in estimation of glaucoma.

The glaucoma rate was significantly higher in male than in female diabetic patients in the present study. However, sex difference in rates of glaucoma in the general population was not significantly different in the Baltimore Study (15). Sex is not a major barrier to access to health care in Oman (7). Hence, the observed higher rates of glaucoma in male diabetic patients need further evaluation.

Ocular changes in diabetic patients are increased in the older population. As the duration of diabetes increases, the risk of ocular changes also increases (16). Thus higher rates of glaucoma in elderly diabetic patients could be due to the confounding effects of duration of diabetes.

Glaucoma rates had significant regional variation in the present study. However, as the sample was selected to represent the study population at national level, regional comparison in absence of sufficient sample should be done with caution. Regional trends could be due to the presence of different tribes with different consanguinity practices. Both glaucoma and diabetes have known genetic and familial etiologies. The consanguinity rate was as high as 38% in Oman (17). This could explain such regional differences in the disease rates.

Levels of ocular pressure for defining glaucoma, ocular hypertension, and normal tension glaucoma vary in different studies. Hence comparison of proportion of these three types of glaucoma to other studies should be carried out with caution. In addition, current specifications to define glaucoma do not stress the level of ocular pressure in defining glaucoma (18). In spite of these limitations, the present study suggests that the mean ocular pressure in eyes with fundus changes of glaucoma was significantly higher than in eyes without retinal/disc changes. Ocular pressure seems to be a practical criterion for suspecting glaucoma. Early detection of glaucoma among diabetic patients by physicians at primary levels could be facilitated by ocular pressure measurement as first level screening. It would be much more feasible to train primary physicians to take ocular pressure than to perform detailed fundus examination for glaucomatous changes in retina and optic disc.

In other studies, open angle glaucoma is more prevalent among patients with type II diabetes than among patients with type I diabetes (10). In contrast, the glaucoma rate was not significantly different among patients with type I and type II diabetes in the present study. Most patients with type I diabetes are under a physician's care and therefore glaucoma detection among these cases by an ophthalmologist in a country with an established reference system is more likely. Patients with type II diabetes usually present in the late stages and tend to be irregular in management and follow-up. Patients with type II diabetes who visit eye clinics are more likely to be health conscious and therefore the rate of glaucoma found among patients with Type II diabetes in this study would be higher than that among all Omani type II diabetic patients. This underestimation of glaucoma rate in type II diabetic patients could be the reason for an insignificant difference in glaucoma rate by type of diabetes in the present study.

Cases with both glaucoma and diabetes had a higher risk of visual impairment than those with only diabetes. However, bilateral blindness was more common among diabetic patients without glaucoma compared to those with diabetes and glaucoma. The role of mild increased ocular pressure in reducing hemodynamics of retina and optic disc resulting in compromised visual functioning was reported earlier (19). The presence of glaucoma among Omani diabetic patients could be protective against advance changes of diabetic retinopathy that are usually responsible for marked visual impairments. However, this postulation needs confirmation through further studies.

In our study, longer duration of diabetes was associated with glaucoma as comorbidity. However, statistical significance of this observation was marginal. Metabolic control of diabetes was noted in few cases and hence the association was inconclusive.

The present study could determine the magnitude of glaucoma among a high-risk population: diabetic patients in Oman. Higher risk groups of combined disease of diabetes and glaucoma included male and older patients. Ocular pressure measurement among diabetic patients could be the first screening test for glaucoma. It should be followed by detailed retinal disc evaluation as second level of screening by ophthalmologists in developing countries with limited resources for eye care of diabetic patients.

ACKNOWLEDGEMENTS

The authors thank the Ministry of Health (national and regional), for undertaking and supporting this study; the health staff, especially ophthalmologists; Saleh Al Harby, for data entry; and Ruth Mabry, for editing.

Reprint requests to:
Rajiv Khandekar, MD
Eye Health Care
DSDC, DGHA, MOH (HQ)
POB: 393
Pin: 113
Muscat, Oman
rajshpp@omantel.net.om

REFERENCES

1. Khandekar R, Mohammed AJ, Negrel AD, Al Riyami A. The prevalence and causes of blindness in the Sultanate of Oman: the Oman Eye Study (OSE). Br J Ophthalmol 2002; 86: 957-62.
2. Thylefors B, Negrel AO. The global impact of glaucoma. Bull World Health Organ 1994; 72: 323-6.
3. Becker B. Diabetes mellitus and primary open angle glaucoma. The XXVII Edward Jackson Memorial Lecture. Am J Ophthalmol 1971; 71: 1-16.
4. Mitchell P, Smith W, Chey T, Healey PR. Open-angle glaucoma and diabetes: the Blue Mountains eye study, Australia. Ophthalmology 1997; 104: 712-8.
5. Ministry of Health, Sultanate of Oman. Annual Health Report year 2001. Oman: Ministry of Health; 2002: 1-4,1-10.
6. Asfour MG, Lambourne A, Ashraf Soliman, et al. High prevalence of diabetes mellitus and impaired glucose tolerance in the Sultanate of Oman: results of 1991 National Survey. Diabet Med 1995; 12: 1122-5.
7. World Health Report. 2000 Health systems: improving performance. 2000: 200.
8. Jawad A, Al Lawati Nizwa. Healthy Lifestyle Project Survey 2001: summary report. Oman: Ministry of Health; 2001.
9. Sarrion Ferre MT, Hervas JM, Blanquer Gregori JJ, et al. Screening for glaucoma in diabetic patients by using the Schiortz tonometer. Aten Primaria 1996; 17: 18-22. PMID: 8742140.
10. Nielsen NV. The prevalence of glaucoma and ocular hypertension in type 1 and 2 diabetes mellitus. An epidemiological study of diabetes mellitus on the island of Falster, Denmark. Acta Ophthalmol (Copenh) 1983; 61: 662-72.
11. Klein BE, Klein R, Jensen SC. Open-angle glaucoma and older-onset diabetes. The Beaver Dam Eye Study. Ophthalmology 1994; 101: 1173-7.
12. Ellis JD, Evans JM, Ruta DA, et al. Glaucoma incidence in an unselected cohort of diabetic patients: is diabetes mellitus a risk factor for glaucoma? DARTS/MEMO collaboration. Diabetes Audit and Research in Tayside Study. Medicines Monitoring Unit. Br J Ophthalmol 2000; 84: 1218-24.
13. Klemen UM, Biber B, Frey C, Gnad HD. Glaucoma, ocular hypertension and diabetic retinopathy. Wien Klin Wochenschr 1985; 97: 616-9. PMID: 4049884.
14. Quigley HA, Vitale S. Models of open-angle glaucoma prevalence and incidence in the United States. Invest Ophthalmol Vis Sci 1997; 38: 83-91.
15. Tielsch JM, Sommer A, Katz J, et al. Racial variations in the prevalence of primary open-angle glaucoma. The Baltimore Eye Survey. JAMA 1991; 266: 369-74.
16. Narendran V, John RK, Raghuram A, Ravindran RD, Nirmalan PK, Thulasiraj RD. Diabetic retinopathy among self reported diabetics in southern India: a population based assessment. Br J Ophthalmol 2002; 1014-8.
17. Sulaiman Ali JM, Asya Al Riyami, Samir M, Farid. Family Health Survey: 60-61.
18. Lee P. Epidemiology and socioeconomic impact of glaucoma. In: Ophthalmic Fundamentals: Glaucoma. Thorofare, NJ: Slack; 2000: 1.
19. Neetens A, Badaniova D. Intraocular pressure and diabetic retinopathy. Bibl Anat 1977; 16(Pt 2): 437-41.