Ongoing Glaucoma Detection Program in Oklahoma

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GLAUCOMA is now the leading cause of irreversible blindness in the United States, accounting for 13.5 percent of the cases of legal blindness (*1*). In the United States approximately 1.2 million people have undiagnosed cases of glaucoma, of which 3,500 terminate in blindness each year (*2*). The necessity for glaucoma detection at an early stage, prior to extensive loss of vision, is therefore apparent.

Glaucoma is a disease which readily fits into the protocol of general screening clinics. It has a parameter, the intraocular pressure, which is a useful indicator for further evaluation. Furthermore, this parameter can be quickly, painlessly, and efficiently measured with results instantaneously available.

Glaucoma detection can be accomplished in many ways. Generally, five major types of programs can be distinguished as follows: (*a*) massive, one-shot screening programs ("G-days"), (*b*) ongoing glaucoma screening programs, (*c*) industrial screening programs, (*d*) screening of hospital admissions (inpatients and outpatients), and (*e*) screening in a physician's office (*3–8*). Ongoing programs have many advantages, as previously described (*3*). These programs may be situated in large metropolitan areas or limited to rural areas. Programs in rural areas, while screening a smaller number of patients, provide glaucoma detection for areas relatively inaccessible to ophthalmological care. Screening in urban locations often reaches a larger segment of a State's population. Thus an optimal program would combine both approaches.

A program's format determines somewhat its space requirements and locality. Clinics which limit the testing protocol to a measurement of visual acuity and tonometry are mobile and can function adequately in any locale. If visual field testing, tonography, and water-provocative testing are employed, the clinics are generally stationary and limited to larger population centers.

Conversely, the clinic locality often affects a program's format by influencing the availability and character of medical supervision. Ophthalmological supervision is rarely available for remote rural areas. In such localities, general medical practitioners or nurses under their supervision perform all screening procedures. In areas accessible to ophthalmological supervision, the screening protocol can be more sophisticated and might even approach a diagnostic examination.

When tonometry alone (usually Schiotz to-

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nometry) with or without visual acuity testing is the sole technique employed, the number of referrals will be directly related to the intraocular pressure referral levels. A level of 25.8 mm. Hg (1955 calibration table, Committee on Standardization of Tonometers), 3 standard deviations from the mean as determined by Becker, is often accepted as a referral level (*9–11*). By statistical definition, at 3 standard deviations from the mean only 0.15 percent of referred persons should not have glaucoma if the reference population was normally distributed (*12*). It has been shown, however, that intraocular pressure measurements do not follow a truly normal distribution. Indeed, Becker found that 7 percent of normal eyes had intraocular pressure greater than 22 mm. Hg—a higher percentage than predicted from the previously cited mean (*11*).

The absolute diagnosis of glaucoma depends to some extent on the ability of the individual nerve head to withstand pressure. Because this is a variable factor, some screening clinics investigate all patients with intraocular pressure of 20 mm. Hg or higher (*13*).

Tonography measures the facility with which intraocular fluid leaves the eye. Water ingestion often makes a subclinical condition tonographically apparent. The P_o/C value is used as a criterion for referral of a patient for further evaluation. It is defined as follows:

P_o—initial intraocular pressure;

C—coefficient of outflow facility, as measured by tonography; and

$P_o/C=100$—2 standard deviations from the population mean (*10*).

The results of a recent study of a young industrial population in Japan suggested that 17.3 mm. Hg should be the level which separates glaucoma suspects from normal persons (*14*). When water-provocative tonography was used as a secondary evaluation technique in that study, 33 percent of the screenees with an intraocular pressure of 17–19 mm. Hg had a $P_o/C>100$ and were therefore considered to be glaucoma suspects. Nevertheless, the level of referral of 17.3 mm. Hg would probably result in a tremendous over-referral rate.

Several large screening programs have reported using 25.8 mm. Hg as the referral level (*15, 16*). In Florida, the incidence of glaucoma in a screening population of 67,193 was 1.5 percent. In that study, any person over age 21 was eligible for screening. In other programs, where the age level was restricted to persons aged 35 or over, glaucoma was detected in 2 percent of the screenees (*4–8*). The problem in all these studies is the definition of a confirmed case of glaucoma, which is usually a case that is diagnosed by the examining ophthalmologist. The basis for his diagnosis may vary from repeat tonometry to an extensive evaluation, thus significantly affecting the statistics.

The glaucoma detection program in Oklahoma was formulated with these factors in mind. An instructional monograph describes the program in detail (*17*).

The following section presents data accumulated during the first 3 years (1964–67) of continuous screening in Oklahoma. In addition, data on tonographic evaluation of 54 consecutively referred patients are presented as a partial evaluation of the specificity rate of our referral criteria.

Oklahoma Program Format

All glaucoma detection clinics in Oklahoma, with two exceptions in industrial areas, are established through county health departments. Three years after implementation of the program, 16 of the 55 counties with organized health departments had continuing glaucoma clinics. A clinic is established only after endorsement is obtained from the county medical society and the county ophthalmologists. The clinics meet on an ongoing basis—weekly, biweekly, or monthly on a specified day and time.

Each clinic is completely autonomous; and each is supervised by the county health director and operated by public health nurses. All tonometry and other procedures are done by the nurses. The protocol for each clinic is standardized according to that suggested by the Oklahoma State Department of Health (*17*). Any person not known to have glaucoma and 35 years of age or older (or over 21 years if there is a family history of glaucoma) is eligible for testing.

Screenees undergo a test of visual acuity and Schiotz tonometry and, based on the tonometry results, they are divided into three groups (table 1). Each patient referred for further evaluation

Table 1. Tonometric criteria, Oklahoma glaucoma detection program

Patient classifications	Scale reading (7.5 gm. wt.)	Equivalent mm. Hg [1]
Referral	0–5	≧25. 8
Borderline	5. 5–6. 5	23. 8–20. 1
Negative	≧7. 0	≦18. 5

[1] January 1955 calibration table.

takes a form to his ophthalmologist, who later returns it to the county health director. On this form the ophthalmologist indicates whether the diagnosis of glaucoma is confirmed, not confirmed, or pending. Persons with borderline cases are informed of their status by the county health director and rechecked yearly. Rechecks are facilitated by filing reminder post cards in a tickler file at the time of initial testing. Each month the secretary need only pull the cards from the past year and mail them to recall the patients. Negative patients are recalled in a similar manner and rechecked every 2 years. An attempt is therefore made to recheck every patient at least every 2 years.

If a referral report is not returned, the public health nurses initiate a followup investigation. Through the persistent and dedicated efforts of these nurses, an ophthalmological evaluation report has been obtained on 96.9 percent of all patients referred for evaluation to date.

The concept of secondary glaucoma evaluation has recently been incorporated in an attempt to reduce the rate of false positive (unnecessary) referrals. A glaucoma evaluation center was established in July 1967, through a Public Health Service grant, at the University of Oklahoma Medical Center. The glaucoma center, operated by the department of ophthalmology and the Oklahoma State Department of Health, functions in three capacities: (*a*) to provide comprehensive glaucoma evaluation of patients found to be positive in State screening programs, (*b*) to provide the same service for private patients where such facilities are otherwise unavailable, and (*c*) to facilitate the instruction of ophthalmological residents at the medical center in the techniques of glaucoma evaluation.

Patients referred from State screening clinics are given the option of direct referral to an ophthalmologist or evaluation at the glaucoma center. The center is staffed by a trained technician under the supervision of two ophthalmologists. The technician performs applanation tonometry and tonography, visual field and acuity examinations, and optic disk photography. Provocative testing is performed, on the request of the referring health director or ophthalmologist, by the staff or private ophthalmologist. All results are reviewed by the staff ophthalmologists, and they decide whether the patients need ophthalmological attention or should merely have periodic rechecks at the county screening center.

The criteria on which this decision is based have been published in detail (*17*). Briefly, the criteria for an abnormal tonometric or tonographic result are based on 3 standard deviations from the mean as determined by Becker (*10*, *11*). Any visual field or optic disk abnormality is referred for ophthalmological evaluation. If such evaluation is advisable, referral is made through the county health department, as described earlier. A copy of all reports and disk photographs are sent to the ophthalmologist.

The center will become self-supporting through fees paid by patients of private ophthalmologists. Patients referred to the screening clinic, if judged by the University Medical Center as unable to pay the standard fee, are charged according to the existing university means scale. Total collection receipts increased from $350 to $2,432 during the second and third

Table 2. Number of screenees with borderline glaucoma and number referred for further evaluation, by age groups

Age group (years)	Screened	Borderline	Referred
Under 35	710	69	3
35–39	804	115	7
40–44	1, 441	243	22
45–49	1, 479	196	41
50–54	1, 281	202	51
55–59	1, 042	207	40
60–64	917	204	38
65–69	789	173	34
70–74	605	121	35
75 and over	531	96	36
Undetermined	47	18	4
Total	9, 646	1, 644	311

quarters of the center's initial year. Thus, an adequate financial base is assured for the center's continuing existence.

Screening Results

During its first 3 years the glaucoma detection program grew impressively. The numbers screened tripled with each successive year for an accumulative total of 9,646. While the number is not great in comparison to other large programs, the early county programs were mainly in small, predominantly rural areas where individuals normally would not receive this service.

Overall totals show that 3.2 percent of the screenees were in the referral category while 17.1 percent were borderline (table 2). Forty-nine percent of the patients referred (1.6 percent of the screenees) were given a confirmed or pending diagnosis by the referral ophthalmologist (table 3).

Tonography was performed on 54 consecutively referred patients from a glaucoma screening program. Using the P_o/C value as a criterion for justified referral, 57 percent were more than 2 standard deviations from the mean ($P_o/C > 100$) while 33 percent were more than 3 standard deviations from the mean ($P_o/C > 138$). The eyes of the former group (greater than 2 standard deviations) had an average P_o of 4.75 scale readings. Those in the latter group (greater than 3 standard deviations) had an average P_o of 4.50 scale readings.

All 31 patients with a $P_o/C > 100$ (2 standard deviations) were subsequently referred for ophthalmological evaluation. Of 18 patients with a $P_o/C > 138$, all but one (94 percent) were found to have clinical evidence of glaucoma by the referral ophthalmologist. Five patients with a $P_o/C > 100$, but less than 138, had clinical evidence of glaucoma—a confirmation rate of 38 percent. The overall rate of confirmed glaucoma for patients with a $P_o/C > 100$ was 41 percent.

Program Costs

A cost analysis of the State screening program has been conducted yearly (*18*). With the exception of the secondary evaluation center (financed separately as described earlier), all costs incurred by the State and county offices are included in the analysis. As expected, the cost per person screened was highest during the first year. A great proportion of medical and nursing time was spent initially in organizational and promotional activities. As the county units became established, more time was spent on actual glaucoma screening. Even the third year costs reflect the expense of establishing new screening units.

During the first year, the cost per screenee was $7.57. By the third year this had been reduced to $3.69. The cost per screenee will continue to decrease as the need for organizational consultation from the State office decreases. Ultimately, instead of a full-time ophthalmological consultant, it is planned to provide ophthalmological consultation on a fee-for-service basis with a public health adviser coordinating the activities. This will significantly lower the cost per screenee since the expense at the State level (as opposed to the county clinic units) accounts for 69 percent of the program costs.

Table 3. Diagnoses made by ophthalmologists, by age groups of referred patients

Age group (years)	Referred	Not confirmed	Confirmed	Pending	Not reported
Under 35	3	2	1	0	0
35–39	7	2	4	1	0
40–44	22	10	5	6	1
45–49	41	23	4	11	3
50–54	51	22	17	12	0
55–59	40	11	15	10	4
60–64	38	20	12	5	1
65–69	34	22	8	4	0
70–74	35	15	13	7	0
75 and over	36	20	13	3	0
Undetermined	4	2	1	1	0
Total	311	149	93	60	9

Discussion

The Oklahoma glaucoma detection program attempts to discover undiagnosed cases of glaucoma by providing direct screening services and enhancing the level of public understanding. The dissemination of information may eventually result in a larger detection rate by stimulating patients to seek an ophthalmic examination. Hopefully, screening clinics will diminish in number and importance as patients receive tonometry at yearly or biyearly intervals through private medical facilities.

The program discussed here attempts to avoid the pitfalls of previous endeavors by the following procedures: (*a*) discovering false negative patients or patients in whom glaucoma (as diagnosed by tonometry) develops later, by rechecking the screening population at yearly or biyearly intervals, and (*b*) attempting to lower the false positive referral rate by providing a secondary evaluation of positive and borderline patients. The ongoing format prevents a referred patient, in whom an ophthalmologist could not confirm glaucoma, from later having undetected glaucoma. Such patients revert to a borderline status if the diagnosis is unconfirmed, and they are rechecked yearly.

As mentioned earlier, the referral level is somewhat arbitrary. Nevertheless, the tonographic evaluation lends support to our criteria. Fifty-seven percent of the referred patients were found to have a P_o/C value more than 2 standard deviations from the population mean. If a strict statistical definition were applicable, no more than 2.5 percent of persons 2 standard deviations from the mean should be expected not to have the disease in question. Applying this statistic to our referral level, at least 43 percent of referred patients should be found to have glaucoma. This calculation, however, is based on two unproved assumptions—that outflow is normally distributed in the population and that the critical P_o/C value is indicative of glaucoma.

The calculated figure is supported by the finding that 41 percent of the 54 consecutively referred patients were found to have clinical evidence of glaucoma by the referral ophthalmologist. Since some unconfirmed cases may later become clinically apparent, we can estimate that nearly half of all referred patients have or will later have glaucoma. It should be further emphasized that 71 percent of the patients with a $P_o/C>100$ and 94 percent with a $P_o/C>138$ were given a confirmed diagnosis. The addition of tonography can therefore be valuable in lowering the false positive referral rate.

The Oklahoma program has demonstrated that a statewide program is feasible and self-sustaining. With one exception, in which unusual local personnel limitations exist, every county program has continued in a productive manner without a loss of popularity or enthusiasm. Interest spreads rapidly to surrounding counties, allowing a projection from current information of 25 to 28 screening programs by the year's end. The cost per person screened is steadily decreasing as clinics become more efficient and productive. Plans for reducing the cost further (as described earlier) have been made. In summation, the glaucoma detection program is now accepted as a permanent structure in the State health department structure, with an established position in the present and future budgets.

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Education Notes

Doctoral Study in Social Work and Social Science. The University of Michigan offers an interdepartmental program which combines social work with economics, political science, psychology, social psychology, or sociology and leads to a doctor of philosophy degree. Social psychology may be chosen as a field of concentration within psychology or sociology.

The program is designed to prepare students for careers in research, teaching, policy development, and administrative positions in the social welfare field. Candidates for a master's degree in social work in 1968–69, experienced social workers, holders of a master's degree in a social science, or persons with a bachelor's degree only may apply.

Support for this advanced study is available from several sources, including the Children's Bureau and the Public Health Service. Stipends range from $1,800 to $3,600 plus tuition.

Fellowship applications must be received by February 1, 1969, and applications for admission only will be received until May 1, 1969.

For detailed information and application forms write to Doctoral Program, School of Social Work, University of Michigan, 1065 Frieze Building, Ann Arbor 48104.

Applied Epidemiology for Physicians. A course in applied epidemiology for physicians will be offered by the Training Program of the National Communicable Disease Center, Public Health Service, November 18–22, 1968.

This course, part of the Center's continuing education program, is directed to physicians who serve as investigators of disease outbreaks or who have administrative responsibility for such investigations. It serves both as a refresher for experienced health administrators and as an introductory medium for physicians new to public health. The course is designed to show how epidemiologic techniques can be used in disease prevention.

Although the course will include lecture-discussion sessions, emphasis will be placed on group participation obtained through the use of group solution of epidemiologic problems, seminar-type presentations, and panel discussions. Audiovisual aids are used in the presentations.

Registrants will be expected to attend all sessions. Additional information and application forms may be obtained from the National Communicable Disease Center, Atlanta, Ga. 30333. Attention: Medical Training Officer, Health Professions Training Section, Training Program.