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OCULAR HYPERTENSION AND CHRONIC OPEN-ANGLE GLAUCOMA IN UNITED STATES AIR FORCE PILOTS AND NAVIGATORS

James L. Mims, III, et al

School of Aerospace Medicine
Brooks Air Force Base, Texas

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James L. Mims III, Major, USAF, MC
Thomas J. Tredici, Colonel, USAF, MC

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Records from the United States Air Force glaucoma screening and management program for flying personnel were surveyed to obtain long-term followup information and age-specific prevalences for this population. Untreated ocular hypertensives with tensions of 22-29 with no visual field loss were labeled "preglaucoma"; ocular hypertensives without field loss and treated with epinephrine (for tensions above 29 or for other reasons) were labeled "glaucoma." Those requiring other drugs and those with field loss were

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disqualified from flying. In tabulating followup information, appropriate compensation was made for those eliminated from the population by disqualification. Two of the 43 preglaucomas and 3 of the 17 glaucomas followed 5 years in the waiver file had been disqualified for field loss. Questionnaires to ophthalmologists caring for retired men indicated that 1 of the 39 preglaucomas followed 8 years and 2 of the 27 glaucomas followed 7 years had lost visual field. Among ocular hypertensives screened from 15,804 men, ages 40-54, in 1970, only 5 had visual field loss presumed glaucomatous. Age-specific prevalences for ocular hypertension were lower than published figures for other populations. The absence of high myopia in this group does not appear sufficient to explain this difference.

PREFACE

The authors gratefully acknowledge the assistance of Col John R. Simmons, USA, MC, Chief, Ophthalmology Service, Brooke Army Medical Center, Ft Sam Houston, Tex.; Capt Bernard R. Blais, USN, MC, Chief, Ophthalmology Service, Naval Hospital, Philadelphia, Pa.; Mr. Don Colston, Ambulatory Care, Central Office of the Veterans Administration, Washington, D.C.; Lt Col Richard W. Sonntag, USAF, MC, and MSgt Lloyd E. Downey, USAF, of the Ophthalmology Service, Wilford Hall Medical Center, Lackland AFB, Tex.; Col Robert E. Matejka, USAF, MC, Physical Standards Division, Office of the Surgeon General, HQ USAF, Randolph AFB, Tex.; Mr. H. J. Sommers, Biometrics Division, Directorate of Plans and Hospitalization, Office of the Surgeon General, HQ USAF, Washington, D.C.; Col C. E. Schutt, Chief, Research and Analysis Division, Directorate of Personnel Plans, HQ USAF, Washington, D.C.; MSgt Jerry Brown, Chief, World-Wide Locator, USAFMPC, Randolph AFB, Tex.; and 147 military, government, and civilian ophthalmologists who provided followup data.

OCULAR HYPERTENSION AND CHRONIC OPEN-ANGLE GLAUCOMA IN USAF PILOTS AND NAVIGATORS

INTRODUCTION

Long-term followup information has not been available previously concerning the development of apparently glaucomatous field loss among ocular hypertensives screened from virtually 100% of a large, nonvolunteer population. No studies reporting age-specific prevalences of ocular hypertension in such a population could be found.

This report is a tabulation of data provided by records, spanning a 15-year period, from the U.S. Air Force glaucoma screening and management program for pilots and navigators. An administrative waiver file used in managing the program provided information for our 5-year followups on glaucoma and preglaucoma cases. Our 7- and 8-year followups (glaucoma and preglaucoma, respectively) were tabulated from waiver-file data and from questionnaires sent to ophthalmologists caring for subjects who had retired. Decrease in sample size (N) in figures illustrating 5-year followup indicates nonsimultaneous initial detection, with no loss to followup. Decrease in sample size (N) in figures illustrating 7- and 8-year followups is due to a combination of nonsimultaneous initial detection and some loss to followup (see Discussion).

The terms "preglaucoma" and "glaucoma" used in this report have been taken from USAF administration manuals for flight surgeons and are not the same as those in current use among ophthalmologists. The preglaucoma group included men with tensions of 22-29 and no disc or field changes (a narrowed angle was not implied). The glaucoma group primarily included men with tensions above 29 and no field loss, whose tensions could be controlled adequately with epinephrine alone. (Thus, many flyers with no field or disc changes were given the label "glaucoma.")

Secondary glaucoma cases and narrow-angle glaucoma cases are not included in these groups. Men in our preglaucoma and glaucoma groups would be labeled in many centers as "ocular hypertensive," "chronic open-angle glaucoma suspect," or "chronic open-angle glaucoma."

METHODS

Flight surgeons perform Schiøtz tonometry on all flyers over age 39 as part of their annual physical examinations. Special training in tonometry has been a part of the initial instruction course given to all flight medical officers since 1961 (3). The requirement for annual

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tonometry was made effective in mid-1963 (4). Referral to the base consulting ophthalmologist is made if a tension of 22-24 is repeatable on two occasions or if a single tension above 24 is obtained. If the ophthalmologist confirms the elevated tensions and makes a diagnosis of chronic open-angle glaucoma, benign ocular hypertension, glaucoma suspect, or similar, then the patient is categorized as shown in Table 1.

TABLE 1. ADMINISTRATIVE LABELS FOR OCULAR HYPERTENSIVES

Preglaucoma	Glaucoma
Normal visual fields	Therapy initiated due to
Normal optic discs	tensions above 29 mm Hg
Tensions 22-29 mm Hg	or for other reasons
No therapy	Controlled by epinephrine

Those who have no field defects or optic disc changes and whose tensions are 22-29 are identified as "preglaucoma." (This term is applied for administrative purposes and does not imply a narrowed angle.) Tension checks by the flight surgeon every 3 months and visual field testing and tensions by the base consulting ophthalmologist every 6 months are recommended.

If the tensions without any medications rise above 29, the man must be treated as indicated by regulation. If he prefers for some reason, such as a large cup-disc ratio with a pale disc, the base consulting ophthalmologist can treat a flyer with tensions below 30. If adequate control without field loss is possible with epinephrine alone, the patient is labeled as having glaucoma and continued on flying status. Adequate control on epinephrine has not been defined by regulation, but in practice this has generally been considered to be tensions of 25 or less without field loss.

If a flyer has visual field loss or needs miotics or carbonic anhydrase inhibitors to control tension, he is disqualified and is no longer within the flying population (8, 14). The accommodative spasm and decreased night vision which miotics produce in a substantial proportion of these relatively young patients are not compatible with the 24-hour capability required of USAF flying personnel (10).

Documentation of adequate ophthalmic care of all ocular hypertensives must be presented annually to the Physical Standards Division of the Office of the Surgeon General, HQ USAF. (If it is not, the patient's flying status is in jeopardy.) In the Physical Standards Division, the preglaucoma and glaucoma labels are verified. The waiver file in the Division office was a major source of information for this study; also, about 66% of the glaucomas and 33% of the preglaucomas were seen clinically at the USAF School of Aerospace Medicine.

Waiver-file data were used to tabulate a 5-year followup for preglaucomas and for glaucomas and to calculate age-specific prevalences for the year 1970. The year 1970 was chosen for the age-specific prevalences because it was the most recent year with centralized reporting and because an efficient system for verifying proper ophthalmic care had been in effect for several years prior.

When waiver-file data were used exclusively, some compensation for those disqualified for miotics or field loss had to be made. Once disqualified, a man was out of the flying population and no longer followed year by year in the waiver file. To compensate appropriately for those disqualified, the average age of retirement for those not disqualified was calculated; this was 49 for both glaucoma and preglaucoma. Each man disqualified was carried forward year by year and counted until he passed age 49. This compensation procedure was used for the 5-year followup tabulations for preglaucoma and glaucoma and for the age-specific prevalences.

Most ocular hypertensives identified by the screening program retired within a few years and were therefore no longer followed in the waiver file. We attempted to extend the followup by means of questionnaires to the patients and their current ophthalmologists. In all cases information concerning visual fields and tensions had to originate from ophthalmologists to be counted.

Information from these questionnaires was combined with waiver-file data to produce the 8-year preglaucoma followup and the 7-year glaucoma followup. No special compensation procedure was required for these extended-followup tabulations because a questionnaire was sent to all patients, irrespective of previous disqualification.

For interest, the numbers of secondary glaucoma and narrow-angle glaucoma from the waiver file for 1970 were also tabulated. Compensation was made for those disqualified prior to age 49 (average retirement age), as described previously for the age-specific prevalences and 5-year tabulations for preglaucoma and glaucoma. The USAF program of nontreatment (close observation) of the preglaucoma category and treatment with epinephrine only of those classified glaucoma has been carried out now for nearly 15 years. Within the last several years the ophthalmologic community has begun to debate the pros and cons of the "clinical school" concepts of glaucoma and glaucoma treatment versus the new "contemporary school" approach (differentiating ocular hypertension from glaucoma). This study follows precisely the latter concept, with some cases having been followed for nearly a decade.

RESULTS

Over 300 pilots and navigators have been identified as ocular hypertensives to date. The 5-year followup for preglaucomas is given in Figure 1. Of an initial group of 211 preglaucomas, 43 were followed 5 years in the waiver file. Of these 43, 25 were still labeled preglaucomas, 12 progressed to glaucoma, 2 were relabeled normal, 2 were disqualified because of miotics, and 2 were disqualified because of field loss at the end of 5 years. Table 2 details the yearly status of the 2 who lost field. Case 7 was picked up on routine ophthalmic examination at age 36, and was one of only two who lost field before age 40.

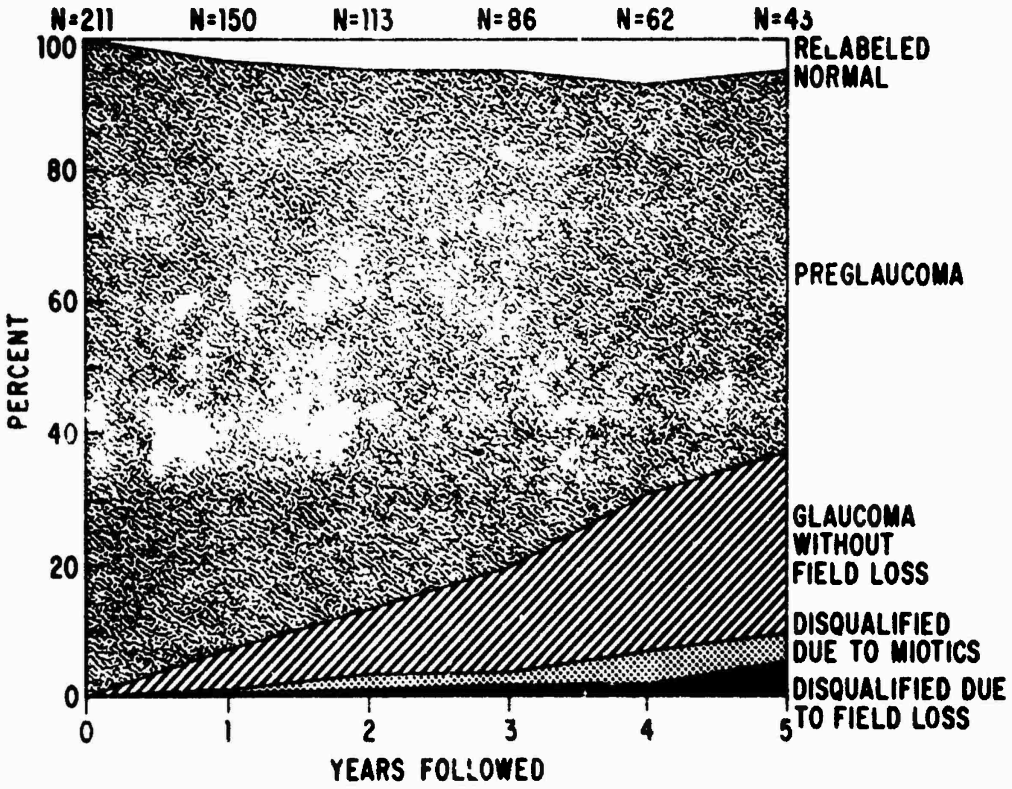

Figure 1. Five-year preglaucoma followup (waiver-file data).

TABLE 2. FIELD LOSS DURING 5-YEAR PREGLAUCOMA FOLLOWUP (WAIVER-FILE DATA)

Case	Year: 0	1	2	3	4	5
#7	P	P	Loss (Age 38)	(Loss)	(Loss)	(Loss)
#4	P	G	G	G	G	Loss (Age 50)

P - preglaucoma
G - glaucoma
Loss - visual field loss discovered
(Loss) - visual field loss carried forward (previous disqualification before average retirement age of 49)

The 5-year followup for glaucomas is given in Figure 2. Of an initial group of 81 glaucomas, 17 were followed 5 years in the waiver file. Of these 17, 11 were still labeled glaucoma, 1 was relabeled preglaucoma, 2 were disqualified because of miotics, and 3 were disqualified because of visual field loss. Table 3 details the years in which the 6 who lost field were counted. Case 8, counted as a field loss in the 5-year followup and the 1970 age-specific prevalence tabulations, was counted as having no field loss in the 7-year followup; he was reported to have enlarged blind spots in 1967-1970, but these were judged to be refraction scotomas in 1973.

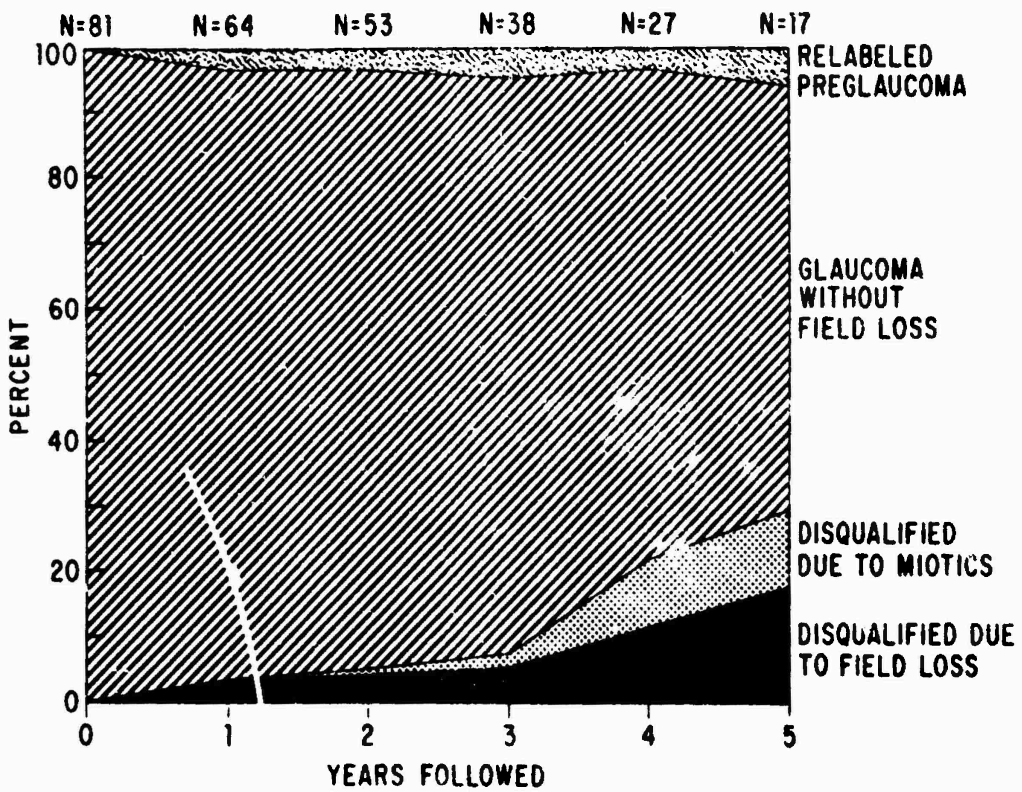

Figure 2. Five-year glaucoma followup (waiver-file data).

TABLE 3. FIELD LOSS DURING 5-YEAR GLAUCOMA FOLLOWUP (WAIVER-FILE DATA)

Case	Year: 0	1	2	3	4	5
# 1	G	Loss (Age 48)	(Loss)			
# 5	G	G	Loss (Age 49)			
# 8	G	G	G	G	Loss (Age 45)	(Loss)
# 9	G	Loss (Age 49)				
#11	G	G	G	G	G	Loss (Age 50)
#12	G	G	G	Loss (Age 45)	(Loss)	(Loss)

G - glaucoma
Loss - visual field loss discovered
(Loss) - visual field loss carried forward (previous disqualification before average retirement age of 49)

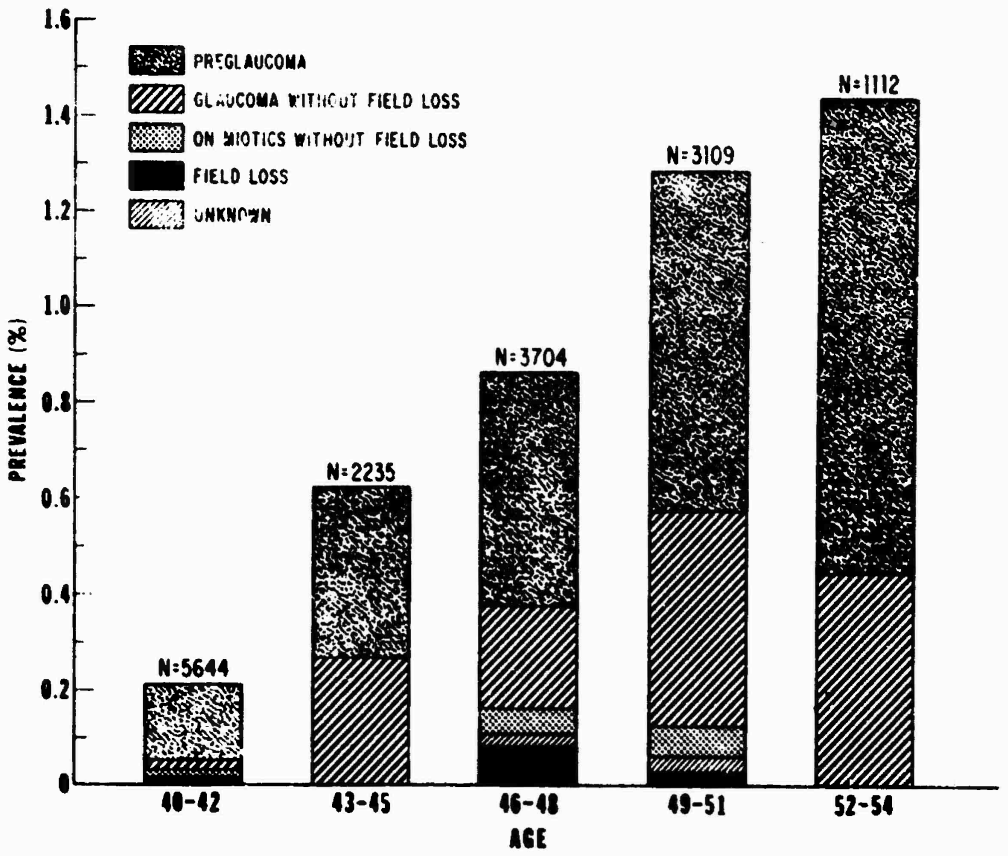

Figure 3. Age-specific prevalences for 1970 as reported to the waiver file.

Age-specific prevalences for 1970 are given in Figure 3. Only 5 of 114 ocular hypertensives screened from among 15,804 were judged to have glaucomatous field loss due to chronic open-angle glaucoma.

For preglaucomas, 8-year followup based on waiver-file and questionnaire data is given in Figure 4. Of an initial 217 preglaucomas, 39 were followed 8 years; at the end, 20 were preglaucomas, 11 were glaucomas, 7 were on miotics, and 1 had field loss. Among the initial 217, 6 lost field sometime during the 8 years (Table 4).

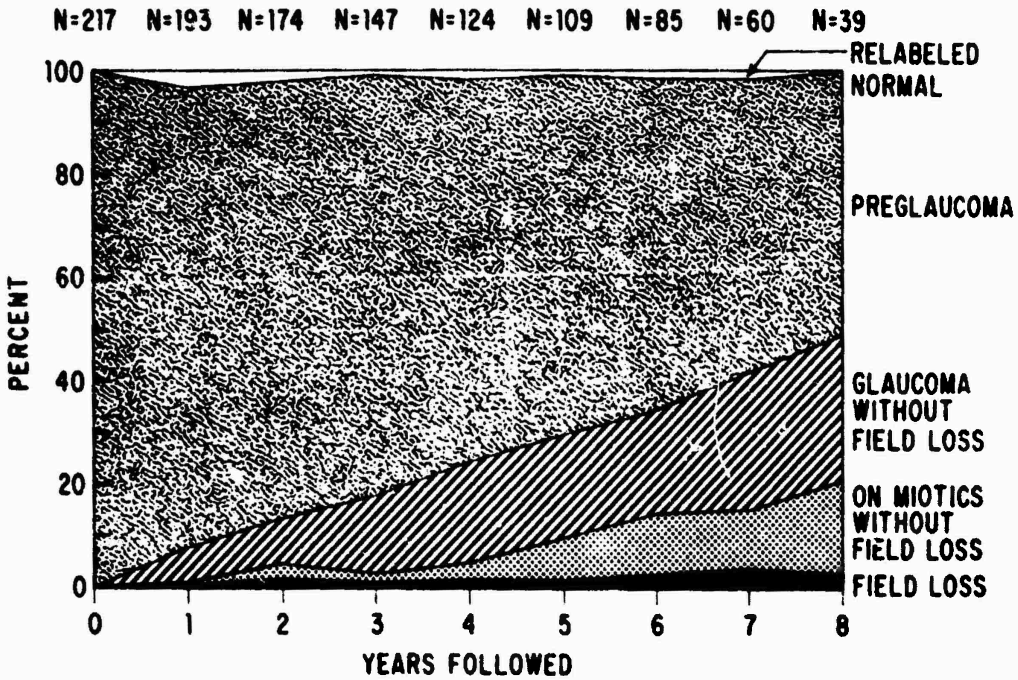

Figure 4. Eight-year preglaucoma followup (waiver-file data supplemented via questionnaires).

TABLE 4. FIELD LOSS DURING 8-YEAR PREGLAUCOMA FOLLOWUP (WAIVER-FILE DATA AND QUESTIONNAIRE)

Case	Year: 0	1	2	3	4	5	6	7	8
# 3	P	P	M	M	M	M	M	Loss	
# 4	P	G	G	G	G	Loss	Loss	Loss	Loss
# 6	P	P	P	Loss	Loss				
# 7	P	P	Loss						
#10	P	P	Loss						
#14	P	G	G	G	G	G	Loss		

P - preglaucoma
M - miotics, 2% pilocarpine, no field loss
G - glaucoma
Loss - visual field loss seen on testing that year

For glaucomas, 7-year followup based on waiver-file and questionnaire data is given in Figure 5. Of an initial 74 glaucomas, 27 were followed 7 years; at the end, 12 were glaucomas, 13 were miotics, and 2 had lost field. Among the initial 74, 7 lost field sometime during the 7 years (Table 5). Case 12 had a brief episode of tensions of 38 O.U., with associated field loss. Tensions were controlled with miotics; and the next available fields, performed 3 years later, were normal.

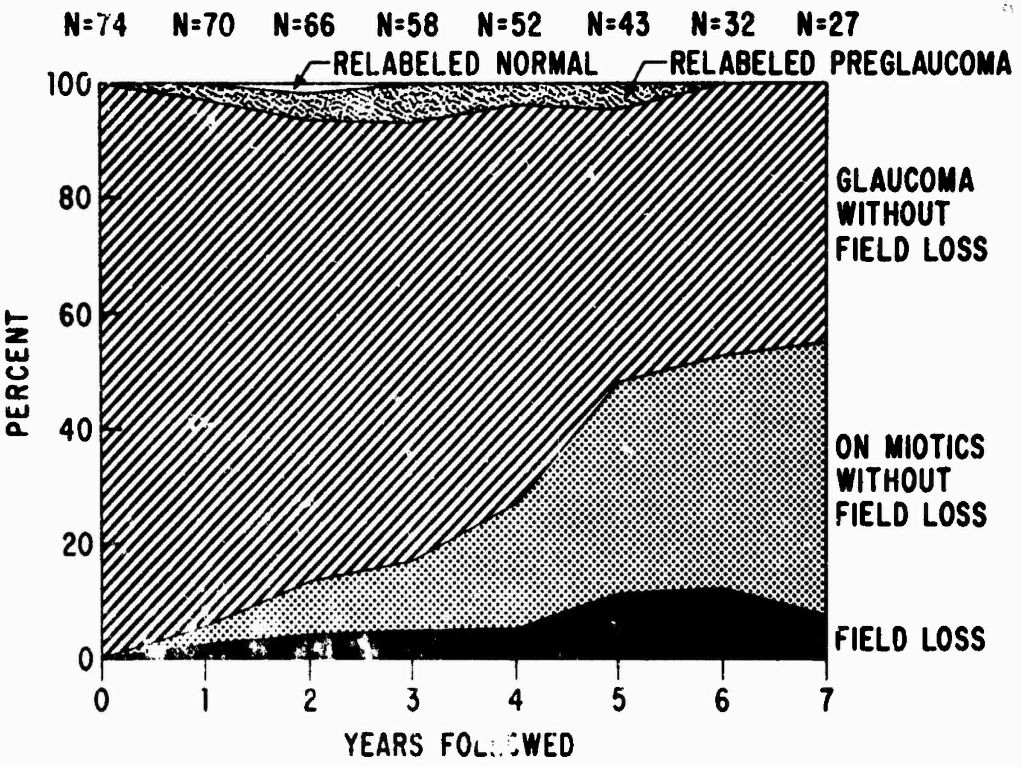

Figure 5. Sever-year glaucoma followup (waiver-file data supplemented via questionnaires).

TABLE 5. FIELD LOSS DURING 7-YEAR GLAUCOMA FOLLOWUP (WAIVER-FILE DATA AND QUESTIONNAIRES)

Case	Year: 0	1	2	3	4	5	6	7
# 1	G	Loss	Loss					
# 2	G	G	G	G	G	Loss	Loss	
# 5	G	G	Loss	Loss	Loss	Loss		
# 9	G	Loss	Loss	Loss	Loss	Loss	Loss	Loss
#11	G	G	G	G	G	Loss	Loss	
#12	G	G	G	Loss			Recovery	
#13	G	G	G	G	G	M	Loss	Loss

G - glaucoma
M - miotics, 2% pilocarpine, no field loss
Loss - visual field loss seen on testing that year
Recovery - first available field after field loss

Types of field loss reported in this study, for each case, are listed in Table 6. Cases 1 to 14 were tabulated in the 5- to 8-year followups. Cases 1, 7, 8, 12, and 15 were counted in the 1970 age-specific prevalences. Table 7 lists tensions recorded at the time field loss was first discovered. Optic disc characteristics were not recorded with sufficient consistency to enable tabulation.

TABLE 6. FIELD LOSS IN CASES WITH NO KNOWN CAUSE OTHER THAN OCULAR HYPERTENSION

Type of field loss	Cases
Arcuate scotoma in Bjerrum area not connected to blind spot	2,9,14,16,17,18,19
Arcuate scotoma in Bjerrum area connected to blind spot	1,3,4,5,6,12*,15
Small individual scotomas in Bjerrum area	1,3,10,15
Roenne nasal step	7,14
Enlarged blind spots	8*,11,12*,13
Peripheral contraction from nasal side	2

*temporary

TABLE 7. TENSIONS RECORDED WHEN FIELD LOSS FIRST DISCOVERED

Case	Tension	Case	Tension
1	24/22	11	28 O.D.
2	22/22	12	38/38
3	Uncertain	13	30/28
4	35 O.S.	14	Uncertain
5	17 O.D.	15	28/29
6	Uncertain	16	30 O.S.
7	22 O.S.	17	36 O.S.
8	Uncertain	18	27 O.D.
9	26 O.D.	19	36 O.S.
10	Uncertain		

Four cases of narrow-angle glaucoma and 11 cases of secondary glaucoma could be counted for 1970. Onset for the narrow-angle cases occurred at ages 47-49, and in at least two cases, detection was due to acute attack rather than the screening program. Onset ages for the secondary cases ranged from 28 to 53; 5 of these were secondary to uveitis, and 6 were secondary to trauma.

The 1970 prevalences of narrow-angle and secondary glaucoma combined were zero for ages 40-44, 0.12% for ages 45-49, and 0.3% for ages 50-54. Information concerning field loss in these cases was not recorded in the waiver file.

DISCUSSION

One major problem encountered in gathering followup information on ocular hypertension is biased data favoring those more severely affected. Patients with symptoms, patients taking eye drops, patients with family histories of glaucoma, and patients whose doctors have expressed concern that they may go blind will seek future medical attention more readily than the routine moderate ocular hypertensive. Theoretically, most of this type of bias should be absent from waiver-file records, because a flyer labeled preglaucoma or glaucoma must have periodic examinations in order to preserve his flying career.

No further information is added to the file after a man retires. Additional information for this study should have been available on 59 glaucomas and 170 preglaucomas via questionnaires; it was obtained on 75% of the glaucomas and 64% of the preglaucomas. This difference indicates a slight bias in favor of the glaucomas, the more severely affected. For this reason we present only waiver-file data in Figures 1 and 2 and waiver-file data combined with questionnaire data in Figures 4 and 5.

On both types of preglaucoma followup tabulations, a substantial shift from the preglaucoma to the glaucoma category occurs over the years. If these men were placed on therapy as a result of rising tensions, this would appear to be in disagreement with the observations of Linner and Stromberg (11). These investigators found moderate ocular hypertension to stay essentially unchanged during 5-year observation of 152 individuals. It would also conflict with Armaly's observations (1) on 1,222 normotensive and hypertensive eyes for a similar period and with Graham's findings (6) on 232 ocular hypertensives followed 43 months.

This shift from preglaucoma to glaucoma apparently represents a tabulation of the physician's behavior in treating ocular hypertension rather than a characteristic of the natural history of ocular hypertension. It probably represents the chance, increasing with time, that a given patient will encounter an ophthalmologist who wants to treat his moderate ocular hypertension.

The low incidence of field-loss development among ocular hypertensives initially having no loss is not unique to this population. It is at least roughly comparable to findings of Linner and Stromberg (11), Armaly (1), and Norskov (12, 13). Higher incidences reported by Schappert-Kimmijser (16) and Leydecker (9) may be due to greater ages of their patients and biased data favoring the more severely affected, as discussed earlier.

Data in Figure 5 and Table 5 indicate that among 43 men initially labeled glaucoma, 4 or 5 had lost visual field after 5 years. Becker and Morton (2) found only 2 with field loss among 50 ocular hypertensives started on epinephrine and followed 5 years. All treated eyes among the ocular hypertensives in Becker and Morton's study, however, had tensions below 30. These probably would have been labeled preglaucoma or normal by USAF criteria.

Becker and Morton also found that epinephrine could not be continued on 80% of their patients because of the side effects. Among our glaucoma cases (Fig. 5), 47% were reported still on epinephrine into the sixth year.

The total number counted as having glaucomatous field loss due to chronic open-angle glaucoma in 1970 was only 5 among 114 ocular hypertensives screened from 15,804 men, ages 40-54. This rarity of field loss for this age group is comparable to other populations in the literature (Table 8). Hollows and Graham (7) found none with glaucomatous loss among about a thousand men in this group, and Stromberg (17) found no more than 1 in 2,000.

TABLE 8. PREVALENCE OF OCULAR HYPERTENSION OF 22 OR ABOVE

Source	Age: 40-44	45-49	50-54
Stromberg (17)	0.9%	1.7%	2.5%
Hollows and Graham (7)	1.2%	2.5%	2.8%
USAF (1970 data)	0.3%	1.0%	1.2%

Our age-specific prevalences for ocular hypertensives are relatively low when compared with prevalences we calculated from Stromberg (17--Grades I-IV hypertension combined for males from Tables 4 and 5) and with prevalences we estimated from graphs of Hollows and Graham (7--Fig. 2). We could not find other studies based on the major portion of a population reported in sufficient detail to allow these age-specific comparisons.

It remains to be demonstrated whether these low prevalences represent underreporting or a bona fide lower prevalence of ocular hypertension among USAF pilots and navigators. The only direct survey of USAF personnel, reported by Dersh in 1961 (5), included nonflying as well as flying personnel and used criteria quite different from the current administrative categories of preglaucoma and glaucoma.

We consider significant underreporting to be unlikely, especially in our 45-49 and 50-54 age groups, because these men have been examined repeatedly on each annual physical examination since age 39. The repeated examinations would tend to produce some overreporting. Questionnaires on 112 preglaucomas indicated that 34% had tensions below the preglaucoma level in their most recent ophthalmic examination. This would be compatible with some overreporting.

In considering what factors in the physical examination standards for flying might produce a lower prevalence of ocular hypertension, the absence of high myopia was considered. Perkins and Jay (15) reported 56 cases of open-angle glaucoma in males under age 50; 40% had more than one diopter of myopia, and more than half of these had a refraction in excess of -4.00 D. Literature reviewed by these authors indicated that myopia is found in 13%-17% of "normal" populations, depending on what criteria are used, generally in excess of -0.50 D. to -1.00 D.

Among 100 USAF pilots and navigators, ages 40-54, referred to our Clinical Evaluation Section for nonocular reasons, 18% had myopia exceeding -0.50 D., 12% exceeding -1.00 D., and only one exceeding -4.00 D. (This one had -4.25 D.) The absence of high myopia in this population may be one reason for the reported low prevalence of ocular hypertension. At best, however, it can account for only a fraction of the difference between this and other populations.

If the relatively low prevalence of ocular hypertension reported in the waiver file can be confirmed by direct survey, further inquiry to determine the reasons for this low incidence may provide valuable insight into factors producing ocular hypertension.

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