Status of Tonometry Surveys as a Source of Epidemiologic Data

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THE COMPARABILITY of Schiotz and Goldmann tonometry in a total community study was recently described (*1*). Results of a subsequent community survey are given in this report to provide a comparison with the original data. Comparing such data from two communities is helpful in appraising and planning epidemiologic investigations of ocular hypertension.

Methods

Survey method. This investigation was undertaken among the population of American Indians living on the Colorado River Reservation near Parker, Ariz. Residents of the reservation are predominantly Mohave, Navajo, and Chemehuevi, but more than 15 other tribes are represented. The study population consisted of all residents of the reservation who were at least one-half Indian and who were age 30 or over at the time of the survey.

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A census of the population was prepared by domicile mapping and individual household interviews. Participation was invited by personal contact at the time of household interview, by prominent display of posters, and by announcements at schools, churches, and tribal meetings. (Faye N. Dollar, R.N., obtained the census and organized the campaign for community participation, and volunteers Peter Homer, tribal chairman, Herman Lafoon, tribal chairman elect, and Agnes Sevilla, chairman of the tribal health committee, were instrumental in encouraging participation.)

The reservation covers an area of about 175 square miles, and examinations were provided successively at five locations. The examinations were completed within 14 days in March 1965.

Of a potential study population of 475 persons, 64 did not participate; thus, the participation rate was 87 percent. The extent of participation is shown below.

Examinations	*Number of participants*
Three completed	396
Three not completed	15
Discontinued (inability to maintain supine position, apprehension, and so forth)	9
Monocularity or severe corneal scarring	6

The age distributions of the segments of the population examined and not examined are shown in table 1.

Clinical method. Three separate examinations were performed on each patient: Gold-

mann applanation tonometry in the sitting position (ASi), Goldmann applanation tonometry in the supine recumbent position (ASu), and Schiotz measurements in the same supine recumbent position. Examination techniques were similar to those reported for the previous study (*1*) among Italian-Americans in Nesquehoning, Pa., with the three following exceptions.

1. Goldmann dial settings were noted by a different observer, and they were recorded to the nearest ½ mm. Hg instead of the nearest ¼ mm. Hg.

2. Applanation measurements on a given eye were continued beyond the minimum number of three more frequently than in the previous study.

3. Two Schiotz instruments were used in Nesquehoning, whereas only one instrument was used at the Colorado River Reservation. The significance of this difference is discussed later.

Results

In the following data all Schiotz scale readings were converted to mm. Hg, using the 1955 calibration table. Each applanation measurement was determined as the median of three consecutive readings according to the procedure described for the Nesquehoning study (*1*).

The cumulative frequency distributions of ocular tension estimated by the three examination techniques and the mean and standard deviation of each distribution are shown in the graph. The cumulative distribution of Goldmann measurements obtained in the supine recumbent position was consistently higher than that obtained by Goldmann tonometry in the sitting position. The distribution for Schiotz measurements was lowest.

Parameters of the distributions of differences between paired measurements taken on each eye are shown in table 2 for ASu minus Schiotz, ASu minus ASi, and ASi minus Schiotz. This table also summarizes the results of our Nesquehoning survey. The mean differences between tonometric measurements by various techniques at the Colorado River Reservation were slightly greater than found in Nesquehoning. The variances of the distributions of paired differences were similar for both communities.

Discussion

The present data confirm an earlier finding (*1*) of disparity among the results of tonometer surveys when examinations are performed by different methods. An extensive discussion of the clinical implication of disagreement among paired measurements was given in the earlier publication (*1*), and this discussion also pertains to the present findings. Systematic differences among tonometric methods would be expected to influence also the results of surveys which are undertaken to obtain descriptions of the prevalence of ocular hypertension. It has been estimated (*2*) that a systematic difference of approximately 2.0 mm. Hg can influence by 60 to 100 percent the proportion of positive screenees identified at the usual range of critical pressure. Table 2 shows 2.0 mm. Hg to be a conservative example of the amount of difference

Table 1. Age distribution of total population and subgroups examined and not examined

Age group (years)	Complete examination		Nonparticipants or incomplete examination		Total	
	Number	Percent	Number	Percent	Number	Percent
30–34	55	13. 9	12	15. 2	67	14. 1
35–39	64	16. 2	11	13. 9	75	15. 8
40–44	67	16. 9	11	13. 9	78	16. 4
45–49	63	15. 9	5	6. 3	68	14. 3
50–54	49	12. 4	5	6. 3	54	11. 4
55–59	39	9. 8	8	10. 1	47	9. 9
60–64	28	7. 1	12	15. 2	40	8. 4
65–69	13	3. 3	7	8. 9	20	4. 2
70 and over	18	4. 5	8	10. 1	26	5. 5
Total	396	100. 0	79	99. 9	475	100. 0

found among different methods of measurement at the Colorado River Reservation.

The inter-method differences found in the Colorado River survey are somewhat greater than reported for Nesquehoning. A closer inspection of this slight inconsistency in the degree of difference between paired examination methods is of interest since it can provide an indirect evaluation of the reliability of individual methods. The reliability of a survey instrument is of critical importance in the collection of comparable epidemiologic data.

Table 2 shows that when Schiotz readings are subtracted from either the ASu or ASi reading, the average difference for the present data was significantly greater than found for the Nesquehoning survey. On the other hand, the differences between applanation measurements in the supine and sitting positions were nearly the same for both communities. Thus, in Nesquehoning the Schiotz method resulted in estimates which were in somewhat closer agreement with both applanation measurements, while the sitting and supine applanation distributions for each community survey maintained a similar relationship to one another in the two studies.

Variation in the difference between Goldmann applanation measurements and Schiotz measurements is not unique among reports by different authors (*3–9*). The use of different equipment by different examiners might account for much of this inconsistency. However, although the field conditions and methods of examination were generally similar in the investigations described here, the differences among paired techniques were not entirely consistent for the two sets of data. This lack of internal consistency among tonometer differences in the separate investigations raises a warning with regard to the reliability of measurements by the individual methods.

Table 2. Summary of the frequency distributions of paired differences between measurements of intraocular pressure by separate methods

Paired difference [1]	Colorado River Reservation, Ariz., 792 eyes		Nesquehoning, Pa., 1,004 eyes	
	Mean (mm. Hg)	S.D. (mm. Hg)	Mean (mm. Hg)	S.D. (mm. Hg)
ASu minus Schiotz	[2] 4. 10	2. 27	[2] 3. 43	2. 54
ASu minus ASi	2. 39	2. 40	2. 31	2. 37
ASi minus Schiotz	[2] 1. 70	2. 54	[2] 1. 12	2. 52

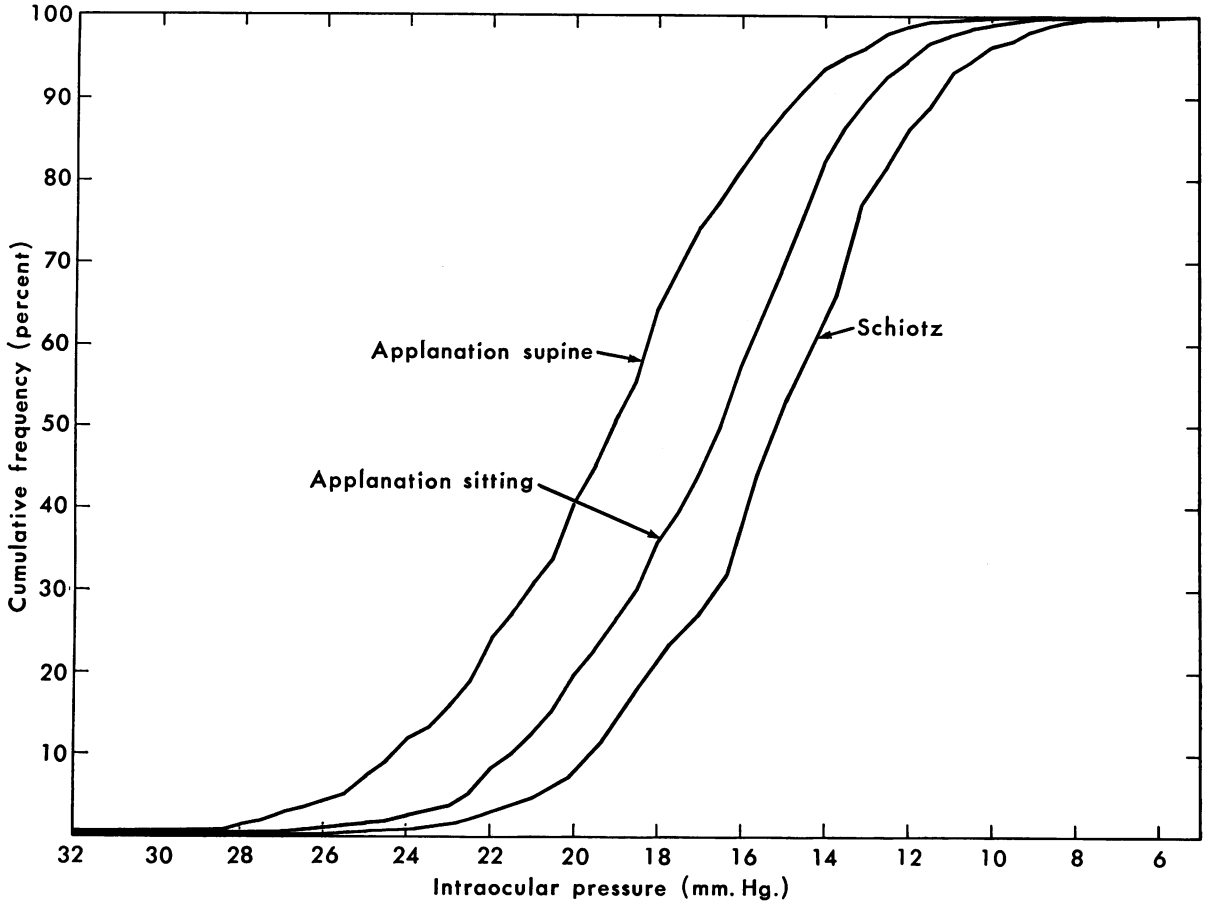
[1] ASu=applanation supine; ASi=applanation sitting.
[2] For these communities, the difference between means of the distributions for both ASi minus Schiotz and ASu minus Schiotz were significant at the 5 percent level. None of the other intercommunity comparisons of means and standard deviations showed a difference which was significant at the 5 percent level.

We have at present no explanation for the discrepancy noted in these two comparisons of applanation and Schiotz measurements. The possible influence of variations in age and sex was considered even though there were only small differences in the composition of the two study populations according to these characteristics. No statistically significant association was found between either of these two variables and the amount of measurement difference among the pairs of examination techniques.

Retrospective evaluation of our field technique does not provide an explanation for the differences between paired measurements which were noted in the two sets of data. Examinations were performed in the same order in both communities; we maintained a similar time interval between examinations and attempted to duplicate examination techniques. In theory, the discrepancy might be attributed to an inconstant performance of the Schiotz tonometers; however, the Schiotz instruments were demonstrated to be capable of equivalent performance both before and after these two field investigations. Because they had been demonstrated to perform similarly, instruments C and E from a previous comparison of Schiotz tonometers (*10*) were used in the Nesquehoning study. At the Colorado River Reservation, instrument E was used almost exclusively. Because the Colorado River survey results suggested a possible change in the performance of instrument E, the Schiotz tonometers were subsequently re-evaluated in a separate field investigation. The performance of instruments C and E relative to one another and relative to reserve instrument A had not altered.

In order to reduce the variation among the accepted set of three consecutive Goldmann applanation measurements, these readings were

Cumulative frequency distribution of intraocular pressure for 3 tonometric techniques on 792 eyes, Colorado River Reservation, Arizona



Method	*Average pressure (mm. Hg)*	*Standard deviation (mm. Hg)*
Applanation supine	19. 08	3. 87
Applanation sitting	16. 69	3. 45
Schiotz	14. 99	3. 30

repeated on each eye more frequently in the Colorado River survey than in the Nesquehoning survey. This change in procedure was also considered as a possible source of the discrepancy between paired differences in Schiotz and Goldmann readings, as found for the two communities. Our accumulated field data suggest, however, that repeated Goldmann measurements tend to be slightly lower than the initial recordings. Thus, continuing the applanation readings on each eye would be expected to lower the level of Goldmann applanation measurements relative to Schiotz measurements. This variation would be expected to reduce the difference between Goldmann and Schiotz measurements at Colorado River, and therefore does not appear to explain the observed difference which was in the opposite direction.

Variations in instrument-examinee interaction must be considered as a possible source of the discrepancy between two populations. For example, a consistent difference in ocular rigidity or corneal pliancy, or both, could induce a systematic variation among measurements obtained with the Schiotz tonometer and possibly also with the Goldmann tonometer (*1*). Thus, a consistent difference in ocular rigidity between the two study populations could contribute to the apparent inconsistency of the Schiotz measurements relative to the Goldmann

measurements. On the other hand, it must be considered that the differences found between the paired Goldmann and Schiotz measurements represent another example (*1*) of a confounding variable which could influence clinical estimates of the coefficient of ocular rigidity.

Whereas known differences in the method of tonometric examinations have been shown to be capable of influencing the results of epidemiologic investigations (*2*), it now appears that reliability of epidemiologic data collected by a single method can be influenced by uncontrolled factors even though similar field conditions are attempted. An explanation of the variability shown in these two surveys will require further investigation. These data provide further support for the contention that a single, carefully detailed procedure for field tonometry must find broad acceptance before it will be possible to obtain comparable descriptive data on the frequency of ocular hypertension.

Summary

In a communitywide survey on the Colorado River Reservation in Arizona, the ocular pressure of 396 examinees was estimated by Goldmann applanation tonometry in the sitting position, Goldmann applanation tonometry in the supine recumbent position, and Schiotz tonometry in the same supine recumbent position.

The results of this investigation confirmed the existence of a wide disparity among tonometric measurements by these methods. A comparison of the data from the Colorado River Reservation survey with a previous communitywide survey of 502 persons in Nesquehoning, Pa., suggested that uncontrolled factors can influence the reliability of measurements made under similar field conditions.

Broad acceptance of a single, carefully detailed procedure for field tonometry seems necessary in order to obtain comparable descriptive data on the frequency of ocular hypertension.

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