OPHTHALMOLOGICAL INVESTIGATIONS OF 500 PERSONS WITH HYPERTENSION OF LONG DURATION*

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FOR many years it has been an established fact that severe changes in the retina, *i.e.*, haemorrhages, exudates, and papilloedema ("retinitis albuminurica") indicate a bad prognosis in patients suffering from hypertension, but the slighter changes have only attracted attention during recent years.

Wagener and Keith (1939) proposed a classification of hypertension into four groups according to the changes in the retina. This classification has many supporters amongst both ophthalmologists and physicians, although their first two groups were based on only 36 patients, whereas Groups 3 and 4 contained 180 patients. Their material appears, in fact, to have been very selected; it consisted almost entirely of patients with the most severe degrees of hypertension, many having nephrosclerosis or malignant hypertension.

Undoubtedly, as the authors themselves stressed, this material gives a false impression of the frequency of the different degrees of retinal changes in hypertension. Bechgaard has shown that malignant hypertension probably does not make up more than 1 per cent. of all cases with this condition. Wagener and Keith's work on the ophthalmoscopic appearances in patients with hypertension aroused considerable interest, and it was expected that pathological changes in the retina would be present in a large number of the patients.

However, retinal changes can only be found with similar frequency in hospitals and clinics where a large number of true malignant cases of hypertension are investigated. It is therefore interesting to determine the frequency with which retinal changes appear in more representative series of cases with hypertension.

It would have been particularly interesting, if our cases had also been investigated ophthalmoscopically, when the hypertension was first diagnosed, but only patients with hypertension of long duration have been studied here. Therefore malignant cases and cases of short duration are automatically excluded. In this respect the material differs entirely from that of Wagener and

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Keith and may be regarded as a supplement to their investigations. For references to the literature refer to Wagener and Keith (1939), and Duke-Elder (1940).

Material and Methods of Investigation

Bechgaard has examined 1,038 out-patient cases of hypertension (325 men and 713 women). At their first examination, from 4 to 11 years earlier, all had had a blood pressure of at least 160/100 mm. Hg or a systolic blood pressure of at least 180 mm. Hg. 485 were re-examined ophthalmologically by Porsaa at the Ophthalmological Department of the Rigshospital. These were all patients who attended the clinic for investigation; patients examined in their homes did not have the supplementary ophthalmic examination. About 97 per cent. of all surviving patients were re-examined; 293 (133 men and 160 women) had died during the observation period.

The different patients were all examined by the same ophthalmologist. The investigation comprised estimation of visual acuity and refraction, examination of the refracting system, and an ophthalmoscopic examination during mydriasis to allow the vessels to be followed to the periphery. The condition of the fundi (arterial diameter, course of the arteries, arterial reflex, arterio-venous crossings, appearance and localization of haemorrhages, presence and appearance of exudates, and condition of the fovea) was described systematically to secure that the examination was as uniform and comprehensive as possible. The ophthalmologist was not informed of the patient's blood pressure before the examination.

In 45 patients other ophthalmological conditions prevented an exact description of the fundi. These were: nystagmus (2), corneal opacity (3), glaucoma (3), high myopia (4), cataract (26), severe astigmatism (2), atrophy of the optic nerve (2), and diabetic retinopathy (1).

Medical Investigation. The material is divided into Wagener and Keith's four groups. It is not clear whether their Group I included cases of hypertension without any vascular changes as well as those with slight changes. Their paper did not contain a Group 0, but like other later investigators we have found it necessary to include such a group for the cases without any vascular changes. The patients in each group are also graded according to their symptoms, which were as follows: headache (44), vertigo (53), nervousness (93), cardiac pain (48), palpitations (60), dyspnoea (56), hot flushes (56), epistaxis (5), previous cerebral haemorrhage (0).

Grade A: no symptoms.

Grade B: slight symptoms.

Grade C: inconvenienced by their symptoms.

Grade D: incapacitated by their symptoms.

FIG. 1.—Group 0. No vascular changes in fundus.

FIG. 2.—Group 1. Slight constriction and sclerosis of the arteries.

FIG. 3.—Group 2. More pronounced changes in fundus.

FIG. 4. Group 3. Haemorrhages or exudates in addition to other vascular changes.

Group 0 (Fig. 1), no vascular changes in fundus, contains 160 patients (37 men, 123 women). The average age is the same for men and women, but the blood pressure of the women is somewhat higher (both systolic and diastolic). In this group the blood pressure is often only slightly raised. The women are more affected by hypertension, and myocardial degeneration is more frequent.

No man in Group 0 had a systolic blood pressure over 200 mm. Hg or a diastolic pressure over 140 mm. Hg.

It is noteworthy that there were 160 patients known to have had hypertension for 10 or more years in whom no retinal vascular changes could be detected even with careful ophthalmic examination. The fact that so many cases had no vascular changes in the fundus seems to us one of the most interesting findings.

Group 1 (Fig. 2), slight constriction and slight sclerosis of the arteries, contains 179 patients (34 men, 145 women). Compared with the patients in Group 0, those in Group 1 are older, they have somewhat higher systolic and diastolic pressures, and their symptoms—especially those of myocardial degeneration—are more frequent.

Group 2 (Fig. 3), more pronounced changes, the arteries are more constricted or more sclerotic, contains 54 patients (19 men, 35 women). The average age for men and women is almost the same, and the patients are on an average a little older than those in Group 1. The blood pressures are considerably higher, and are the same for men and women. The frequency of myocardial degeneration amongst the men of this group is twice that in Group 1. There is no marked increase in symptoms.

Group 3 (Fig. 4), haemorrhages or exudates in addition to other vascular changes but no papilloedema, contains only thirty patients (10 men, 20 women); cases of diabetes and branch-thrombosis have been excluded. The average age is somewhat higher than in Group 2, the distribution of blood pressure the same. In this group the men are more inconvenienced by their symptoms. The frequency of myocardial degeneration is not higher than in Group 2, and it is remarkable that 75 per cent. of the women and 66 per cent. of the men show no sign of myocardial degeneration in spite of the severe retinal changes.

Group 4, papilloedema in addition to haemorrhages and exudates, contains only one case. This fact corresponds with our general view that in an average cross-section of hypertensive patients cases of malignant hypertension are extremely rare, since it most often appears as a relatively acute disease in middle age.

Ophthalmological Investigation.—In addition to papilloedema the condition of the vessels and the presence of exudates and haemorrhages are the facts of special interest in the investigation of the fundi in hypertension. The condition of the arteries may be ascertained from their diameter, the arterio-venous crossings, the course of the arteries, and the arterial reflex. The scheme needed for assessing the arterial diameter is shown in Table I.

TABLE I
Retinal Arteries in Hypertension

Condition of Arteries	Men		Women		Total	
	Number	%	Number	%	Number	%
Normal	72	68	219	66	291	66
Narrow	27	25	77	23	104	24
Very narrow	13	12	31	9	44	10
Isolated spasms	5	5	25	8	30	7
Greater areas of arterial spasm	3	3	9	3	12	3
Obliterated arteries	2	2	2	1	4	1
Slight irregularities in calibre	18	17	71	21	89	20
Severe irregularities in calibre	15	14	14	4	29	7

Diameter of the Arteries.—The estimation of the size of the arteries depends on a general judgment (relation to the size of the veins), but it must be pointed out that *all* the examinations were performed by the same ophthalmologist. No measurements were recorded, as it is impossible to obtain a correct figure, and they are therefore of no value, as they cannot be compared with the standard diameters. The findings are shown in Fig. 5 relation to the patient's age, systolic and diastolic blood pressures, and general health. The ordinate indicates the percentage of cases with abnormal arterial diameters, and it is clear from the table that there is a positive correlation between the increase in blood pressure and the number of abnormal arterial diameters; this is most pronounced in relation to the diastolic blood pressure.

There is no correlation between the age and the abnormalities, the record is almost horizontal, and abnormalities are almost constant at about 35 per cent.

Irregular calibre was seen in 27 per cent. of the older patients, usually after the age of 60 years, and in 50 per cent. of these cases the systolic blood pressure

FIG. 5.—Diameter of the arteries.

was less than 200 mm. Hg; the diastolic blood pressure was also of no significance for the frequency of the irregularities in calibre.

Spasms were most frequently found in the younger individuals at systolic blood pressures exceeding 200 mm. Hg or diastolic exceeding 110 mm. Hg. Spasms were relatively rare, occurring in only 10 per cent. of the cases (6 per cent. had systolic blood pressures over 200 mm. Hg).

The relation between the general condition of health and abnormal arterial diameter has also been recorded, and it appears that in Grades A, B, and C, the number of patients with normal arterial diameters is twice those with abnormal diameters. Only in Grade D was there a slight predominance of abnormal diameters.

Arterio-Venous Crossings.—(Table II) Fig. 6 suggests that there is a considerable positive correlation between the increasing blood pressure (especially the diastolic blood pressure) and the number of cases with abnormal arterio-venous crossings. Further it can be seen that over 50 years of age there is no relation between the

FIG. 6.—Arterio-venous crossings.

TABLE II
Arterio-Venous Crossings in Hypertension

Condition of Crossings	Men		Women		Total	
	Number	%	Number	%	Number	%
Normal	73	68	205	62	278	63
Depression of vein	25	23	87	26	112	25
Sideways displacement of vein	10	9	35	11	45	10
Arched elevation of vein	12	10	35	11	47	10
Venous compression with peripheral dilation	1	1	3	1	4	1
Vein concealed on either side of artery	15	14	24	7	39	9
Tapering of vein towards artery ...	4	4	7	2	11	2
Common sheath of vein and artery	0	0	1	1	1	1

age and the number of cases with abnormal arterio-venous crossings, but below 50 there is perhaps a positive correlation.

Regarding the relation between the general health and the arterio-venous crossings, in Grades A, B, and C the number of normal crossings is twice the abnormal, while in Grade D there are four times as many abnormal crossings as normal. Severe compression of the vein with peripheral dilatation is rare.

Course of the Arteries.—(Table III) There is a considerable positive correlation between increasing blood pressures, both systolic and diastolic, and the number of cases with abnormal arterial courses. The correlation is, however, less marked than that between the blood pressure, the arterial diameter, and the arterio-venous crossings. Fig. 7 shows that over 50 years of age there is no positive correlation between the age of the patient and abnormal courses of the arteries. The abnormalities amount to about 30 per cent.; under 50 years of age there is a slight positive correlation.

The soft curves of the arteries seem to have the closest correlation with raised blood pressure. The relation between the general health and the course of the arteries shows that in Grades A, B, and C contain twice as many cases with a normal course as with an abnormal, while in Grade D the numbers are equal.

TABLE III
Course of the Retinal Arteries in Hypertensive Subjects

Course of Arteries	Men		Women		Total	
	Number	%	Number	%	Number	%
Normal	83	78	256	76	339	78
Abnormally tortuous	11	10	47	14	58	13
Very tortuous with typical soft curves, as if artery is too long in proportion to vein with rectangular crossings of veins	22	21	38	11	60	14

FIG. 7.—Course of the arteries.

Arterial Reflex.—(Table IV) It appears that copper-wire and sheathing are rare, and silver-wire arteries do not occur. Fig. 8 shows a positive correlation between the blood pressure and the number of cases with abnormal reflex, as in the course of the arteries. The lines have practically the same slope as those for the course of the arteries, but they are displaced upwards, showing a higher average percentage of abnormality. The meaning of this displacement is, however, doubtful. Over 50 years of age there seems to be no positive correlation between the arterial reflex and the age of the patient; the abnormalities amount to about 50 per cent.

TABLE IV
Arterial Reflex in Hypertensive Subjects

Arterial Reflex	Men		Women		Total	
	Number	%	Number	%	Number	%
Normal	70	65	167	50	237	54
Sharp, light	40	37	151	45	191	43
Broad	36	34	122	37	158	36
Copper-wire	6	6	2	1	8	2
Silver-wire	0	0	0	0	0	0
Partially sheathed	3	3	5	2	8	2
Totally sheathed	2	2	1	1	3	1

FIG. 8.—Arterial reflex.

Retinal Veins.—The condition of these veins is recorded in Table V.

Pulsation in the Central Vein.—The frequency of spontaneous pulsation in the central vein is as shown in Table VI.

Pathological Changes.—Very few haemorrhages and exudates were found; Group 3 contained only thirty cases, though patients with only one haemorrhage or patch of exudate were included in this group. This figure is small compared with that of Wagener and Keith. Group 4 contained one case with blurred disks; papilloedema was not seen. In the whole material there was only one patient in Wagener and Keith's Group 4.

Visual Acuity.—(Table VII) 91 per cent. of all cases had a visual acuity of 6/12 or over. Visual acuity of 6/18 or below was due to central chorioretinitis; it was present in ten men and 24 women.

TABLE V

Retinal Veins in Hypertensive Subjects

Retinal Veins	Men		Women		Total	
	Number	%	Number	%	Number	%
Normal	90	84	292	88	382	87
Dilated	6	6	7	2	13	3
Dark	10	9	12	4	22	5
Tortuous	10	9	17	5	27	6
Sheathed	2	2	0	0	2	1
Thrombosed	2	2	4	1	6	1

TABLE VI

Pulsation in the Central Vein in Hypertensive Subjects

Pulsation	Men		Women		Total	
	Number	%	Number	%	Number	%
Spontaneous	93	87	304	91	397	90
Non-spontaneous	14	13	29	9	43	10

TABLE VII

Percentage Distribution of Visual Acuity

Acuity	6/6	6/9	6/12	6/18-6/24	6/36-6/60	< 6/60
Percentage	79	8	4	5	1	3

Discussion

The severest retinal changes are scarcely represented. Blurred disk edges were found in only one, and haemorrhages and exudates in only thirty cases.

The objects of this investigation were to establish the frequency of the various vascular changes in the retina in the common form of hypertension of long duration; to correlate the relation of these changes to the blood pressure and the age; and to gain an impression of which changes have the greatest diagnostic value. The condition of the veins gives little information, so interest is focused mainly on the arteries.

Arterial Diameters.—Normal diameters were found in 50 per cent. of the patients, narrow or very narrow arteries in 34 per cent., irregularities of calibre in 27 per cent.—seen usually in older people with relatively low blood pressures. Spasms were seen in only 10 per cent., mostly young patients with higher blood pressures.

Arterio-Venous Crossings.—These were normal in 63 per cent.; in the remaining 37 per cent. the vein was found depressed; real compression, however, was rare (seen in four patients, 1 per cent.).

Course of the Arteries.—This was normal in 72 per cent.; amongst the abnormal the typical soft curves were most closely related to the increased blood pressure.

Arterial Reflex.—This was normal in 54 per cent.; in the remaining 46 per cent. the reflex deviated from the normal, but copper-wire arteries and sheathing were only found in 4 per cent. There were no silver-wire arteries.

Pathological Changes.—These conditions in the retinal vessels in hypertension are of much less importance than is generally believed. The retinal vessels were still normal after many years of hypertension in 38 per cent., and in 42 per cent. they showed only slight changes (Wagener and Keith's Group 1). Severe changes without retinopathy were seen in 13 per cent. (Wagener and Keith's Group 2), and only 7 per cent. of the cases had retinopathy (Wagener and Keith's Groups 3 and 4). Apart from exudate and papilloedema there was little correlation between the condition of retinal vessels and the general clinical condition. Amongst the patients in Group 0, with normal retinae, were many both with considerable symptoms from their hypertension and with hypertensive cardiac disease, and in Groups 2 and 3 many patients had no symptoms from their hypertension and showed no signs of cardiac disease.

Vogelius and Bechgaard are publishing in this issue the results of the examination of the fundi in 124 elderly persons with normal blood pressures, which they made in order to gain an impression of which facts might be of use for the differentiation between purely hypertensive, and purely arterio-sclerotic changes in the retina. Apart from haemorrhages, exudates, papilloedema, and spasms, which were not found in this control material, the same types of changes were found as in the patients with hypertension. There was only one difference, that vascular changes were found in patients with hypertension at an earlier age.

Further, it might be stressed that in hypertension the characteristic abnormality of the arteries is usually their narrow diameter, while in arterio-sclerosis it is their irregularity.

It seems that the effect of the hypertension on the retinal vessels, at any rate as far as the slighter changes are concerned, is primarily an acceleration of the arterio-sclerosis which often develops without hypertension at a later age (between 55 and

60 years). Consequently, the presence of such changes, especially spasms and narrow arteries, below 55 years suggests hypertension; on the other hand the absence of retinal changes does not exclude even an advanced stage of hypertension.

The fact that there is a positive correlation between the blood pressure, both systolic and diastolic, and the appearance of vascular changes in the retina, cannot be ignored, but a slight correlation with the age can also be demonstrated. Both the degree and frequency of the vascular changes increase with the age of the patient in both the control material and the patients with hypertension, but this increase is more rapid in the control material. This fact is difficult to explain.

Wagener and Keith's system of four groups has contributed most valuably to the description of the different degrees and forms of retinal changes and has provided a clear nomenclature. It has also been helpful in the medical assessment of the condition of the patients with hypertension. It cannot, however, be recommended as the main medical classification and sole prognostic guide in hypertension, as has been the tendency in recent years. The changes in the retina are only a sign, like many others in hypertension, and, excepting the relatively rare exudates and papilloedema, they are much less significant for prognosis than, for example, the condition of the myocardium. As mentioned in the introduction only Wagener and Keith's Groups 3 and 4 are based on a sufficient number of patients to justify a prognostic conclusion, so that this classification appears to have little prognostic value in the less severe groups. In most cases of hypertension the condition of the retina alone is useless as a prognostic indicator. As has been stressed by Rogers and Palmer (1947), Peet and Isberg (1946), and Hammarström and Bechgaard (1950), the changes in the heart, kidneys, and brain, and the age and sex of the patient, which appear to have been ignored in previous works, must also be taken into consideration.

Summary

- (1) 485 hypertensive persons were examined medically and ophthalmologically 4 to 11 years after the hypertension had first been detected.
- (2) The retinal vessels were normal in 160.
- (3) The most severe retinal changes were scarcely seen. Only one case with blurring of the disk edge and thirty cases with haemorrhages and exudates were found.

- (4) The arterial diameters were normal in 50 per cent. of the patients, narrow, or very narrow in 34 per cent. and irregular in 27 per cent.
- (5) The arterio-venous crossings were normal in 63 per cent., in the remaining 37 per cent. the vein was found to be depressed, but real compression was rare.
- (6) The course of the arteries was "normal" in 72 per cent. Amongst abnormalities the typical soft curves are most closely related to the raised blood pressure.
- (7) The arterial reflex was normal in 54 per cent. The remaining 46 per cent. had reflexes deviating from the normal. Copper wire arteries and sheathing were only found in 4 per cent. There were no silver-wire arteries.
- (8) When the cases were classified according to Wagener and Keith's classification no convincing correlation between the degree of change in the retinal vessels and the condition of the patient was found. Quite normal fundi were often found after many years' severe hypertension in persons who were severely affected by their hypertension, and who had signs of myocardial damage, while there were definite changes in the retinal vessels in many cases with no symptoms and a normal electrocardiogram.

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