Essential Hypertension

A Twenty-Year Follow-Up Study

By Donald J. Breslin, M.D., Ray W. Gifford, Jr., M.D.,
and John F. Fairbairn II, M.D.

This follow-up study was undertaken to clarify the natural history of essential hypertension. Information of this type is indispensable to evaluation of therapy for this disease.

Keith, Wagener, and Barker in 1939 demonstrated the value of their classification of hypertensive changes in the retina as an aid to prognosis in hypertensive patients. However, the number of patients with milder forms of hypertension in that series was small and the study covered a period of less than 10 years. Consequently, we thought that a more extensive investigation of the prognostic value of ophthalmoscopic findings and other criteria would be desirable.

Material and Method

This study was based on 631 cases in which essential hypertension was first diagnosed at the Mayo Clinic in 1940. The follow-up period was at least 5 years in 557 cases and at least 20 years in 540. An attempt was made to obtain follow-up information for all patients with group-3 or group-4 hypertension. However, to prevent the number of cases of group-1 and group-2 hypertension from becoming unwieldy, follow-up information was sought from every patient in these categories who was seen in the first 6 months of 1940 and from only every third patient who was seen in the last 6 months of 1940.

Patients with a systolic blood pressure of 160 mm. Hg or more or with a diastolic pressure of 90 mm. or more, or with both, were considered hypertensive. Only 17 patients in the entire series failed to have at least one recorded diastolic-blood-pressure reading of 90 mm. or more, and all these had a systolic pressure in excess of 160 mm. Of the 540 patients traced for at least 20 years, 159 had only one blood-pressure determination recorded at the Mayo Clinic, 218 had two or three recorded, and the remainder had more than three recorded. "Average blood pressure" refers to the average of all readings recorded during examination in 1940; in some cases readings were numerous. For patients who had only one blood-pressure determination recorded, that determination was taken as the "average."

Every patient had an ophthalmoscopic examination by an ophthalmologist. The sole basis for grouping was the appearance of the retina according to the Keith-Wagener-Barker criteria. Since originally Keith, Wagener, and Barker did not clearly state how groups 1 and 2 were distinguished, we accepted Barker's criteria in which the degree of sclerosis was the determining factor (personal communication). Patients with minimal or no sclerosis of the retinal arterioles were put in group 1 irrespective of the degree of arteriolar narrowing, provided hemorrhages and exudates were absent. Patients with arteriolar sclerosis of grade 1 or more were put in group 2 if exudates and papilledema were absent. Patients with retinal hemorrhages but without exudates or papilledema were included in group 2. Patients with one or more retinal exudates, with or without hemorrhage but with no papilledema, were included in group 3. Group 4 included only those patients with papilledema.

No effective hypotensive agents were available during the first decade represented by this study. Some of the 43.3 per cent of patients who survived into the last decade received antihypertensive drugs when they became available. However, no attempt was made to separate those who received medical treatment from those who did not, since, from the information available to us, it was impossible to judge whether treatment had been effective in reducing blood pressure and how long and how faithfully the patients had followed a medical regimen.

Follow-up information was obtained by letter from the patient or from his family or physician, by progress examinations at this clinic, or by a combination of these.

Although most patients were aware that they previously had hypertension, survival rates were calculated, by the ad hoc method, as from the

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The Section on Biometry and Medical Statistics, Mayo Clinic, gave helpful advice and provided the statistics that appear in this paper.

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time of diagnosis at the Mayo Clinic in 1940. The average age of the entire series at the time of diagnosis (53 years for men and 54 years for women) was used to calculate the expected survival of a normal population for comparison (figs. 1, 2, and 3).

Because so few patients in group 4 survived 10 or 20 years, this category has been omitted from most of the tables and treated separately in the text.

Results

Age and Sex

Mean age at the time essential hypertension was diagnosed in 1940 was 48.9 years in group 1, 57.3 in group 2, 52.2 in group 3, and 46.5 in group 4. In group 1 there were 52 men and 74 women; in group 2, 134 men and 145 women; in group 3, 105 men and 46 women; and in group 4, 53 men and 22 women. Mean ages of men and women were approximately the same in groups 2 and 3. On the average, in group 1 the women were 6.6 years older than the men; in group 4 they were 4.0 years younger.

Survival

Survival data are given in figures 1, 2, and 3 and in tables 1 and 2. In each group the survival rates were definitely lower than those for the normal population of the same age and sex distribution. Five patients with group-4 hypertension survived 10 years and three survived 20 years from the time of diagnosis at the Mayo Clinic. In most previous series reported, the mortality rate for patients with group-4 (malignant) hypertension was 100 per cent in from 5 to 10 years.1, 3-6

Prognosis was better for patients who had no complications of hypertension than for the entire group (tables 1 and 2).

Relationship of Sex to Survival

Within each ophthalmoscopic group the prognosis was worse for men than for women (figs. 2 and 3). The difference was greatest in group 2 in which the 10-year survival rate for men was one half that for women while the 20-year survival rate for men was one fifth that for women (fig. 2).
Table 1

Ten-Year Survival Rates for Hypertensive Patients with and without Complications

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<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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<tr>
<td></td>
<td>Patients traced</td>
<td>Per cent surviving</td>
<td>Patients traced</td>
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<tr>
<td>Entire series</td>
<td>M</td>
<td>F</td>
<td>B*</td>
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<tr>
<td>Uncomplicated hypertension</td>
<td>47</td>
<td>65</td>
<td>74.5</td>
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<tr>
<td>Average diastolic blood pressure</td>
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<tr>
<td>&lt; 100 mm. Hg</td>
<td>24</td>
<td>32</td>
<td>75</td>
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<tr>
<td>100-119</td>
<td>21</td>
<td>26</td>
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<td>0 or grade 1</td>
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<td>54</td>
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<td>Cardiomegaly (x-ray)</td>
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*Both males and females.
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<td>7</td>
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<td>44.1</td>
<td>50</td>
<td>46.8</td>
<td>85</td>
<td>56</td>
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</table>

*Both males and females.*
### Relationship of Various Ophthalmoscopic Findings to Survival

It has already been shown that prognosis varied with the ophthalmoscopic classification. However, within each ophthalmoscopic group the survival rate was usually lower for patients who had more than grade-I generalized and focal arteriolar narrowing than for those who had less severe arteriolar narrowing (table 3).

Patients with group-2 hypertension who had retinal hemorrhages had a poorer survival rate than did patients of the same group who did not have retinal hemorrhages.

Men with group-3 hypertension manifested by a single exudate in one eye had no better survival rate than did men who had multiple exudates. On the other hand, women with a single exudate in one eye had almost three times as great a survival rate at both 10 and 20 years as did women who had multiple exudates.

The presence of retinal vascular accidents seemed to have an adverse effect on survival in group 2. However, in group 3, survival was better in patients with vascular occlusion.

Severity of generalized and focal arteriolar narrowing was directly correlated with the level of diastolic blood pressure (table 4).

### Relationship of Diastolic Blood Pressure to Survival

Increasing level of diastolic blood pressure was associated with decreasing survival rate more often than not (tables 1 and 2). Some of the exceptions to this apparent tendency may be related to the fact that the number of patients in certain categories is small.

Of 36 patients whose average diastolic blood pressure was greater than 139 mm. Hg, none survived 20 years and only two survived 10 years.

### Relationship of Renal Status to Survival

Proteinuria of grade 2 or more was found in 13 per cent of patients with group-1 hypertension, in 22 per cent with group-2, and in 57 per cent with group-3. It was a grave prognostic sign, for in each group the survival rate for patients with proteinuria of grade 2 or more was appreciably less than that for pa-
patients with proteinuria of grade 1 or less (tables 1 and 2).

The survival rate was also diminished for patients in groups 2 and 3 who had increased values for blood urea (no values were increased in patients of group 1). None of five patients with a blood-urea concentration of 71 mg. or more per 100 ml. survived 10 years. Only three of 41 patients with a blood-urea concentration from 41 to 71 mg./100 ml. survived 10 years, and only one of these survived 20 years.

**Relationship of Cardiac Status to Survival**

Prognosis was less favorable for patients with hypertension of group 2 or 3 who had an inverted T wave in lead I of the electrocardiogram than for patients in the same group who did not have this abnormality (tables 1 and 2). Cardiomegaly as determined by roentgenograms of the chest was associated with a decreased survival rate for patients in group 2 as compared with the rate for the entire series. In patients of group 3, however, cardiomegaly had no adverse effect on either the 10-year or the 20-year survival rate.

Only two patients with group-1 hypertension had congestive heart failure, and neither survived 10 years. History or signs of congestive heart failure in patients with group-2 or group-3 hypertension were associated with decreased survival rates as compared to the rates for the entire series. Only two patients with congestive heart failure survived 10 years and only one survived 20 years. A woman with group-4 hypertension who had congestive heart failure survived 8 years.

The number of patients with angina pectoris was too small to provide reliable data, but prognosis seemed to be affected adversely in all groups. Only one patient in group 1 and five in group 2 had definite evidence of previous myocardial infarction, and only one of these survived for 10 years; none survived for 20 years. No patients in group 3 had a definite diagnosis of previous myocardial infarction. One of three women in group 1 who had angina survived 20 years, and three of 10 men in group 2 who had angina survived 10 years.

**Relationship of Cerebral Vascular Accident to Survival**

Only three of 24 patients with group-2 hypertension and a history of cerebral vascular accident lived longer than 10 years and only one lived longer than 20 years. None of 12 patients with group-3 hypertension and a history of cerebral vascular accident survived 10 years.

**Relationship of Obesity to Survival**

Comparison of those whose weight was more than 30 per cent above their standard for height and age with those in the same ophthalmoscopic group whose weight was not greater than 30 per cent above their standard showed no striking correlation between obesity and survival within any group. In group 3 the survival rate for 14 obese patients was actually better than the rate for the nonobese patients. In group 1 the effect of obesity was not significant except perhaps for a minimal adverse

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*Standards used for desirable weights were those of the Metropolitan Life Insurance Company, Statistical Bulletin, volume #40, November-December 1959, derived from data of the build and blood pressure study, 1959, Society of Actuaries.

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Effect on the 20-year survival rate for men, but only seven obese men were traced for that period (tables 1 and 2). In group 2 the survival rate was somewhat higher for both men and women whose weight was less than 30 per cent above standard than for those considered obese (tables 1 and 2).

**Relationship between Ophthalmoscopic Grouping, Level of Diastolic Blood Pressure and Incidence of Complications**

The incidence of many of the complications that adversely affect life expectancy in the hypertensive patient had a close positive correlation with severity as indicated by ophthalmoscopic grouping. The data in table 5 might be interpreted as indicating that the higher mortality rate of patients in the higher Keith-Wagener-Barker groups is simply due to the higher incidence of cardiovascular complications and the higher average diastolic blood pressure among these patients. However, tables 1 and 2 indicate that for each level of blood pressure, as well as for each complication (except for congestive heart failure) for which adequate data are available, the prognosis with regard to life expectancy worsens from the lower to the higher ophthalmoscopic groups.

**Group-4 (Malignant) Hypertension.** The 75 patients with group-4 hypertension had a high incidence of cardiovascular complications. Twenty had a history or signs of congestive heart failure, 65 had proteinuria of grade 2 or more, and 68 had an average diastolic blood pressure of 120 mm. Hg or more, but in only nine was body weight more than 30 per cent above standard. Twenty-two of 58 patients whose electrocardiograms were available had inverted T waves in lead I. Twenty-five of 73 with determinations of blood urea had elevated values. Cardiac enlargement was demonstrated in 39 of 72 patients who had roentgenograms of the chest. Twelve patients had a history of cerebral vascular accident, 10 had retinal vascular accidents, and two had angina pectoris. None of the patients with group-4 hypertension had definite evidence of previous myocardial infarction.

Brief reports on the five patients with group-4 hypertension who survived 10 years or more follow.

**Case 1.** A white man aged 48 years who came to the Mayo Clinic on February 5, 1940, had been found in 1933 to have hypertension. He complained of occasional occipital throbbing, sometimes occurring in the morning. His blood pressure initially was 220/140 mm. Hg. Average of all determinations made during examination was 202/124 mm. Hg. His weight was 60 per cent above standard for his height and age. Ophthalmoscopic examination revealed hemorrhages, no exudates, bilateral papilledema, and severe arteriolar changes. The electrocardiogram showed left axis deviation and the roentgenogram of the chest showed slight cardiac enlargement. Urinalysis revealed proteinuria, grade 1, and pyuria, grade 1. Blood urea measured 28 mg./100 ml. Treatment with potassium thiocyanate was started. The

### Table 5

**Relationship between Ophthalmoscopic Grouping and Certain Clinical Findings or Complications of Hypertension**

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<thead>
<tr>
<th>Finding</th>
<th>Fundus group</th>
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<tr>
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<tr>
<td>Ten-year mortality rate</td>
<td>19</td>
</tr>
<tr>
<td>Twenty-year mortality rate</td>
<td>54</td>
</tr>
<tr>
<td>Diastolic blood pressure, &gt; 120 mm. Hg</td>
<td>8</td>
</tr>
<tr>
<td>(Generalized) retinal arteriolar narrowing, &gt; grade 1</td>
<td>11</td>
</tr>
<tr>
<td>Focal retinal arteriolar narrowing, &gt; grade 1</td>
<td>3</td>
</tr>
<tr>
<td>Inverted T waves in electrocardiogram†</td>
<td>7</td>
</tr>
<tr>
<td>Cardiomegaly by roentgenogram†</td>
<td>9</td>
</tr>
<tr>
<td>Proteinuria, grade 2 or more†</td>
<td>13</td>
</tr>
<tr>
<td>Blood urea, &gt; 40 mg./100 ml†</td>
<td>0</td>
</tr>
</tbody>
</table>

*Percentages have been rounded off to nearest whole numbers.
†Percentages based on number of patients tested.
patient died of a cerebral vascular accident on July 18, 1950.

Case 2. A white woman aged 52 years who came to the Mayo Clinic on September 8, 1940, had been found in the previous April to have hypertension. The history suggested that she had a cerebral infarction in August 1940. She had morning frontal headaches. Her blood pressure initially was 230/150 mm. The average of all determinations made during observation was 230/155 mm. The optic fundi showed retinal hemorrhages, exudates, edema residues, papilledema of 2 diopters bilaterally, and severe narrowing, sclerosis, and focal constrictions of the retinal arterioles. She had grade-3 proteinuria and a blood-urea concentration of 68 mg./100 ml. The roentgenogram of the chest showed marked cardiac enlargement. T waves were inverted in lead I of the electrocardiogram. Treatment was started with theobromine and phenobarbital. The patient died in 1951 of unknown cause.

Case 3. A white woman aged 31 years who came to the Mayo Clinic on February 26, 1940, had been found in June 1939 to have hypertension. Her only complaint was occipital headache, which was neither severe nor frequent. The initial blood pressure was 218/130 mm. The average of all blood pressure measurements during observation was 206/123 mm. Ophthalmoscopic examination revealed retinal hemorrhages, papilledema, and rather severe arteriolar changes. She had a harsh, grade-III systolic murmur over the entire precordium. The electrocardiogram showed inversion of T waves in standard lead I. The roentgenogram of the chest revealed moderate cardiac enlargement. Urinalysis disclosed grade-4 proteinuria, a few hyaline casts, occasional erythrocytes, and a few leukocytes. Blood urea measured 42 mg./100 ml. Excretory urography gave negative results. Treatment with potassium thiocyanate was started. In 1948 bilateral dorsolumbar sympathectomy was performed. The patient was alive on October 3, 1960.

Case 4. A white man aged 48 years who came to the Mayo Clinic on March 30, 1940, had been found the previous month to have hypertension. He complained of early morning headache, loss of 40 pounds in 2 months, and frequency of urination. Blood pressure initially was 250/140 mm., and the average of all determinations was 233/137 mm. Ophthalmoscopic examination revealed papilledema, hemorrhages, exudates, and severe arteriolar narrowing and sclerosis. Urinalysis disclosed grade-3 proteinuria, grade-1 to -2 microhematuria, and grade-3 pyuria. Blood urea measured 68 mg./100 ml. The electrocardiogram showed a diphasic T wave in lead I and left axis deviation. Treatment with potassium thiocyanate was started in 1940. The patient died on June 18, 1960, of unknown cause.

Case 5. A white woman aged 17 years who came to the Mayo Clinic on November 21, 1940, had been found 1 month previously to have hypertension. Her complaints included hyperhydrosis, weight loss, headache, and decreasing vision. Her blood pressure initially was 185/150 mm. Ophthalmoscopic examination showed severe generalized and focal arteriolar narrowing, multiple hemorrhages, edema residues, and papilledema. The electrocardiogram and the roentgenogram of the chest showed no abnormality. Urinalysis revealed grade-2 proteinuria, and the blood urea measured 22 mg./100 ml. Excretory urography showed no abnormality. The basal metabolic rate was +25 per cent. She had persistent tachycardia throughout hospitalization. The average of all blood-pressure readings was 178/138 mm. Orthostatic hypotension was recorded on one occasion. Consulting endocrinologists thought that she did not have hyperthyroidism, and adrenal exploration was considered but never carried out. Treatment with potassium thiocyanate was started. Subtotal thyroidectomy was carried out elsewhere in September 1941. Preoperatively the basal metabolic rate was +86 per cent. Also in 1941 her right eye was removed because of glaucoma. In 1947 she had a normal pregnancy without complications. In 1951 a cataract was removed from the left eye. She has continued to take various antipressor drugs with satisfactory control of her blood pressure. She has not had an adrenal operation. She was living and well and able to do normal household duties in July, 1963.

Effect of Sympathectomy

The number of patients in this series who had sympathectomy is too small (16) to provide significant information. Of the men with group-3 hypertension the only two 20-year survivors had had sympathectomy. Of the 93 men with group-3 hypertension who died, six were known to have had sympathectomy. Of the three 20-year survivors with group-4 hypertension, one woman had a sympathectomy in 1947.

Causes of Death

In the series, known causes of death included coronary and other cardiac disease, 48 deaths; cerebral vascular disease, 35 deaths; and uremia, 12 deaths. Thirty-three deaths were not related to hypertensive disease.

Discussion

Various attempts have been made to study

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the natural history and to establish a classification of essential hypertension that will be generally acceptable and meaningful in terms of prognosis of the untreated disease. Bechgaard7 has correctly observed that, because of the modern widespread use of antihypertensive drugs, such studies must now be retrospective and will become increasingly difficult as further time elapses. Results in the present series have been affected to an unknown degree by therapy, for several of the patients had sympathectomy and it is likely that many who survived longer than 10 years received various types of antipressor drugs and with unknown effectiveness.

The Keith-Wagener-Barker1 grouping of hypertensive patients according to the appearance of the optic fundi was a major step in the formation of a suitable system of classification. However, some ophthalmologists believe that significant retinal arteriolar sclerosis may occur in normotensive persons with increasing age. This had led to some reluctance to accept the Keith-Wagener-Barker classification of hypertensive subjects, particularly as it applies to milder hypertension. In their 1939 paper, Keith, Wagener, and Barker1 said that patients in group 1 show only minimal changes in the retinal arterioles, whereas those in group 2 “usually show moderate to marked sclerosis of the retinal arterioles.” Such changes were thought to correlate well with the ratio of arteriolar lumen to wall, as seen in muscle biopsy specimens from those patients. Their survival curves supported the prognostic validity of their classification. However, their series contained only 10 patients in group 1 and 26 in group 2.

Since 1939, various authors, including Palmer and colleagues,8 Smithwick,9 Hammarströme and Bechgaard,10,11 Perera,12 Page,13 and Sokolow and Perloff14 have modified the classification of hypertensive patients in various ways to make allowance for such factors as height of diastolic blood pressure, presence or absence of varying degrees of cardiac, cerebral vascular and renal complications, and sex of the patient, in addition to the appearance of the optic fundi. Such systems are useful in evaluating the hypertensive patient. However, each approach differs slightly from the others, and none has become generally accepted. Since a classification solely on appearance of the retina is certainly the simplest of these approaches, it became desirable to have as much information as possible about the validity of this method. Surprisingly little information is available regarding the prognostic value of grouping of hypertensive patients based solely on ophthalmoscopic appearance, with particular regard to distinguishing between groups 1 and 2. Table 6 summarizes several relatively comparable series in this respect.

The fairly low mortality rate reported for patients with group-3 hypertension in the series of Palmer and co-workers8 (table 6) may be explained by the fact that they based their grouping on the degree of damage to the most severely involved system. Thus, a patient who had suffered a stroke might be placed in a higher group than ophthalmoscopic appearance alone would place him. The re-

| Authors, date, and reference no. | Patients | Group 1 | | Group 2 | | Group 3 | | Group 4 | |
|---------------------------------|---------|--------|--------|--------|--------|--------|--------|--------|
| Simpson and Gilchrist, 195815    | 299*    | 44     | 38     | 55     | 38     | 94     | 74     | 100    | 100    |
| Breslin, Gifford and Fairbairn, 1964 | 557     | 11     | 5      | 38     | 19     | 68     | 54     | 94     | 81     |
| Keith, Wagener and Barker, 19391 | 108*    | 30     | 46     | 46     | 46     | 80     | 99     |        |        |
| Palmer, Loofbourrow and Doering†, 19488 | 430    | 10     | 25     | 25     | 25     | 48     | 90     |        |        |
| Frant and Groen, 195014         | 128     | 15     | 27     | 27     | 27     | 60     | 100    |        |        |

*Hospitalized patients.
†Group determined by clinical status in addition to Keith-Wagener-Barker criteria.
maining series adhered strictly to ophthalmoscopic appearance in grouping their patients. In the series of Simpson and Gilchrist,\textsuperscript{15} the relatively high mortality rates, particularly in groups 1 and 3, may be attributed in part to the fact that their patients were all ill enough to require hospitalization.

Several authors\textsuperscript{15, 17, 18} have pointed out that a casual blood-pressure determination, as compared to average basal blood-pressure determinations with the patient at rest, is relatively unreliable in prognosis. Although many of the blood-pressure readings obtained in our series were “casual,” the height of the average diastolic blood pressure correlated well with the degree of retinal arteriolar narrowing (table 4). Our data indicate that evaluation of fundus changes helps safeguard against attributing unwarranted significance to transient increases of blood pressure observed on “casual” determination. Thus, as was previously noted, it should be stressed that for any given level of diastolic blood pressure the prognosis worsened from the lower to the higher ophthalmoscopic groups.

The data also indicated that for any given complication except congestive heart failure the prognosis was adversely affected by higher ophthalmoscopic grouping.

Almost as important as the appearance of the optic fundus in determining prognosis was the sex of the individual. Many investigators\textsuperscript{1, 8–10, 15, 19–22} have observed that the prognosis is poorer for men than for women in the same hypertensive group. In Bechgaard’s\textsuperscript{21} series of 1,038 hypertensive subjects, 41.6 per cent of women and only 18.5 per cent of men were alive after 16 to 22 years of observation. In our series, the 10-year survival rate for women in group 1 was 86.2 per cent, which is extremely close to the expected survival rate for a similar group of women in the general population (88.5 per cent). After 20 years the survival rate for women with group-1 hypertension was somewhat less than that for normotensive women (fig. 2).

We have no satisfactory explanation for the relatively low incidence of coronary artery disease as manifested by angina pectoris at the time of diagnosis in 1940. Electrocardiographic diagnosis of myocardial infarction in 1940 was severely limited by the routine use of only four leads and this may partly explain the low incidence of myocardial infarction at that time.

Summary and Conclusions

For 540 traced patients among 631 patients first given the diagnosis of essential hypertension at the Mayo Clinic in 1940, the 10-year and 20-year survival rates were lower than for the normal population of the same age and sex distribution and correlated well with the ophthalmoscopic grouping of hypertensive patients according to the criteria of Keith, Wagener, and Barker. Women survived longer than men in each group.

Although ophthalmoscopic grouping was positively correlated with severity of diastolic hypertension and incidence of certain complications, this correlation alone could not explain the decreased survival rates in the higher ophthalmoscopic groups. For each level of diastolic blood pressure, the prognosis worsened from the lower to the higher ophthalmoscopic groups. Similarly, such complications as azotemia, proteinuria, and inverted T wave in the electrocardiogram had an increasingly serious prognostic import from the lower to the higher ophthalmoscopic groups. Ophthalmoscopic grouping also provided excellent prognostic information in uncomplicated hypertension.

Myocardial infarction, congestive heart failure, and cerebral vascular accident were each associated with high mortality rates than that for the entire number of patients within each ophthalmoscopic group.

In patients with group-2 hypertension, those with cardiomegaly had a poorer prognosis for survival than did those without it, but among patients with group-3 hypertension cardiomegaly did not seem to lessen longevity.

In patients with group-1 or group-2 hypertension survival rates for the obese were very slightly lower than those for the nonobese in the same group. Obesity did not seem to have an adverse effect on survival in patients with group-3 hypertension.

It is concluded that changes in the optic
fundi as classified originally by Keith, Wagen-
er and Barker remain the simplest, the most
practical, and the most accurate guide to
prognosis in essential hypertension, with or
without complications.

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