Systolic Hypertension in the Elderly
An Epidemiologic Assessment

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SUMMARY
Isolated systolic hypertension (systolic blood pressure of 160 mm Hg or greater, diastolic blood pressure less than 90) was investigated in the Leisure World population at Seal Beach, California. The prevalence of this condition was 13.9% if the blood pressure at the initial examination was used but dropped to 2.7% if the subsequent two determinations of blood pressure were also reviewed.

Seventy-two of the subjects with persistent systolic hypertension were compared with 72 matched normotensive control subjects. Cardiovascular morbidity and mortality were generally more frequent among subjects with systolic hypertension. That this association is causal has yet to be proven.

In this elderly population isolated systolic hypertension was a labile, relatively infrequent condition associated with an increased risk of developing cardiovascular complications.

Additional Indexing Words:
Cardiovascular morbidity  Prognosis  Diabetes  Cerebrovascular disease
Cardiothoracic ratio  Coronary disease  Congestive heart failure

ISOLATED systolic hypertension is generally thought to be a frequent and benign manifestation of aging due to stiffening and loss of distensibility of the large arteries. Many physicians feel that in the presence of a normal diastolic pressure, elevation of systolic blood pressure in the older individual is of little prognostic significance and requires no therapy.

Evidence supporting these beliefs is difficult to find. Virtually all studies of the prognosis associated with systolic hypertension have utilized young and middle-aged populations.1,2 While these studies appear to show an adverse effect of systolic blood pressure elevation, the question remains as to whether this also applies to elderly individuals.

Routine medical surveillance of an elderly population has provided a unique opportunity to observe the frequency of systolic hypertension, its associated cardiovascular conditions, and its prognosis.

Method
The Leisure World in Seal Beach, California, is a retirement community of approximately 10,500 people, south of Los Angeles. The medical clinic located on the premises had 9,382 patients registered as of June 1, 1968. The Heart Disease and Stroke Control Program of the United States Public Health Service, in conjunction with the medical clinic, has been operating a medical surveillance system for epidemiologic investigations since 1962, when the community first opened.3,4 From that time, all registrants at the clinic have received a complete initial medical examination at the time of entry. During this examination a single measurement of blood pressure was obtained routinely by the clinic staff physicians and nurses who were not asked to modify

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their usual method of casual blood pressure measurement.

Between March and August 1965, a cohort of all individuals who had received an initial examination by that time was identified. A representative 4% sample was selected for follow-up by using all individuals whose second last register number digit was 2, 4, 7, or 9. The present study of systolic hypertension utilized the medical records of this sample of 3,245 persons with follow-up continuing through March 31, 1968. The records of those persons who had an initial systolic blood pressure of 160 mm Hg or greater and a diastolic pressure less than 90 mm Hg were selected for special review of the subsequent two blood pressure determinations, whenever they were recorded. If in either of the subsequent two determinations found in the medical record the systolic blood pressure fell below 160 mm Hg or the diastolic blood pressure rose above 90 mm Hg that individual was not considered to have systolic hypertension for the purposes of this study. Persons who had other medical conditions including aortic insufficiency, severe anemia (less than 10 g hemoglobin/100 ml), hyperthyroidism, arteriovenous fistula, or fever at the time of blood pressure measurement were also eliminated from the study group.

To select a control group of normotensive individuals to compare with those meeting all the criteria for isolated systolic hypertension, lists were prepared of all persons whose systolic blood pressure was less than 140 mm Hg and whose diastolic blood pressure was less than 90 mm Hg. Each list contained those normotensive individuals whose diastolic blood pressure was within a specified 5-mm interval. Persons with systolic hypertension were taken according to their clinic register number and the corresponding list of normotensive subjects was examined to find the person who most closely matched the hypertensive subject with regard to age, sex, and diastolic blood pressure. No control subject was used more than once. If a suitable control subject was not available within the specific 5-mm blood pressure grouping, adjacent 5-mm blood pressure groups were searched. A person was considered a suitable control if he was of the same sex, if his diastolic pressure matched within 10 mm Hg, and if his age matched within 5 years. Because of evident blood pressure lability and the need to have a clearly contrasting comparison group, the second and third blood pressure determinations in the medical record of each potential control were checked and those persons with any blood pressure over 140/90 were discarded. Some subjects with systolic hypertension could not be matched with any normotensive individual and were not included in the study of associated cardiovascular conditions and prognosis.

The medical records of the hypertensive and control subjects were reviewed for evidence of coronary artery disease, cerebral vascular disease, peripheral vascular disease, diabetes mellitus, and congestive heart failure. The criteria used to determine the presence or absence of these conditions were as follows: stroke—well-defined symptoms and physical findings of a neurologic deficit of sudden onset; angina pectoris—classical symptoms of precordial chest pain initiated by exertion and relieved by rest or nitroglycerin; myocardial infarction—symptoms of severe chest pain with characteristic QRS changes on electrocardiogram or enzyme changes (SGOT above 50), or both; intermittent claudication—calp pain evoked by walking and relieved by rest; diabetes mellitus—fasting or postprandial levels of blood sugar of 130 mg/100 ml or greater; congestive heart failure—the presence of pulmonary vascular congestion on physical examination or x-rays, or evidence of an elevated venous pressure. Conditions occurring before entry often lacked adequate documentation and the opinion of the examining physician was accepted in these cases. Cardiothoracic ratio was measured by one of us (MAC), using chest x-rays without knowledge of whether or not the patient was hypertensive or normotensive. It was not practical to examine other study variables obtained from medical records in this blind fashion.

Results

Overall Study Group

The 3,245 subjects consisted of 1,244 men and 2,001 women. The mean age of the men was 69.7 years at the time of the examination and was 68.3 years for the women. The age distribution for each sex is shown in figure 1.

Relation of Mean Blood Pressure to Age

The distribution of the mean systolic and diastolic blood pressures in all subjects according to age was consistent with the belief that systolic blood pressure rises with age in both sexes (fig. 2). The mean systolic blood pressure in females rose from 133.4 mm Hg in the group under age 55 to 165.0 mm Hg in the group aged 85 or more; in males the rise was from 128.4 to 154.0 mm Hg with a peak at 156.1 mm Hg in the 75 to 84 age group. The diastolic pressure, on the other hand, varied over a much narrower range and did not show any consistent rise with age.

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Prevalence of Systolic Hypertension

Utilizing the initial blood pressure determination, 451 (13.9%) of the subjects met the criteria for isolated systolic hypertension. In men the prevalence was 14.9% (153 of 1,244) and in women, 12.3% (298 of 2,001). Most of these subjects did not show persistent systolic hypertension when their second and third blood pressures, measured at subsequent clinic visits, were reviewed. The systolic blood pressure fell below 160 mm Hg in 227 subjects. Diastolic blood pressure rose above 90 mm Hg in 65 subjects. In 27 subjects the systolic blood pressure fell and the diastolic blood pressure rose. Twenty-nine subjects were excluded because their records did not contain three blood pressure readings. Fourteen patients were excluded because of evidence of aortic insufficiency, hyperthyroidism, or anemia.

The remaining 89 subjects with persistent isolated systolic hypertension represented 2.7% of the total study population. The prevalence in men was 2.1% (26 of 1,244) and in women, 3.1% (63 of 2,001). The prevalence increased with age within the age span studied.

Characteristics of the Study Group

Of the 89 subjects with persistent systolic hypertension, 72 (24 men and 48 women) were matched with suitable control subjects. The subjects who could not be matched with suitable controls were primarily women over the age of 78 with diastolic blood pressures over 85 mm Hg.

The mean age of the 72 subjects with systolic hypertension was 69.1 years as compared to 68.9 years for their matched controls. The average follow-up period was 47.9 months for the hypertensive subjects and 49.0 months for the control subjects. The mean diastolic blood pressure for the hypertensive subjects was 78.9 mm Hg, and the mean diastolic blood pressure of the control subjects was 78.1 mm Hg. Two hypertensive subjects had diastolic blood pressures 8 mm higher and one had a diastolic pressure 6 mm lower than their corresponding control subjects. In the remaining 69 pairs of individuals the difference in diastolic blood pressure ranged from +4 to −4 mm Hg.

The criterion of selection that differentiated the two groups was, of course, the systolic blood pressure. The average systolic blood pressure was lower in the hypertensive group than in the control group. The difference between the groups was 16.0 mm Hg. The mean systolic pressure in the hypertensive group was 150 ± 19.4 mm Hg and in the control group, 134 ± 23.5 mm Hg.
pressure among the hypertensive subjects was 172.2 mm Hg and that of the control subjects was 127.3 mm Hg, a difference of 44.9 mm Hg.

Morbidity and Mortality (Table 1)

Coronary Heart Disease and Congestive Heart Failure

Nine cases of myocardial infarction were found among the subjects with systolic hypertension. Four patients had historical evidence of infarction occurring before entry into the study and five developed infarction after entry into the study. In the control group, two patients had evidence of infarction prior to examination, one sustained an infarction following examination, and one had two infarctions, one before and one after examination. Angina pectoris was present in eight hypertensive subjects at the time of entry examination and developed later in five others. In contrast, the control group included three patients with angina pectoris at entry and two additional patients who developed this symptom later. While the differences were not statistically significant, manifestations of coronary heart disease were more frequent in the patients with systolic hypertension. A history of congestive heart failure was given at entry by one patient with systolic hypertension, and symptoms of congestive heart failure developed in five others. In the control group three subjects had evidence of prior congestive heart failure, and five subsequently developed congestive heart failure.

Cerebral Vascular Disease

Six persons with cerebrovascular accidents were included in the hypertensive group and two in the control group. Five of the six strokes in the subjects with systolic hypertension occurred after examination and thus their records were available for review. Two episodes were classified as transient ischemic attacks and two were diagnosed as cerebral thrombosis on the basis of hospital records including spinal puncture. The etiology of the stroke in one case could not be determined. One of the two strokes in the control group occurred after examination and was a transient ischemic attack.

Intermittent Claudication

Three systolic hypertensive subjects had intermittent claudication, in two prior to entry and in one later. Two normotensive subjects

### Table 1

<table>
<thead>
<tr>
<th>Findings</th>
<th>Systolic hypertensives (n = 72)</th>
<th>Normotensives (n = 72)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Myocardial infarction</td>
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<td>12.5</td>
</tr>
<tr>
<td>Angina pectoris</td>
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<td>18.1</td>
</tr>
<tr>
<td>Congestive failure</td>
<td>6</td>
<td>8.3</td>
</tr>
<tr>
<td>Stroke</td>
<td>6</td>
<td>8.3</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>19</td>
<td>26.4†</td>
</tr>
<tr>
<td>Intermittent claudication</td>
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<td>4.2</td>
</tr>
<tr>
<td>Mortality</td>
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</tr>
<tr>
<td>Total</td>
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<td>11.1</td>
</tr>
<tr>
<td>Cardiovascular</td>
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<td>9.7†</td>
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<td>Electrocardiogram</td>
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<tr>
<td>Left axis deviation</td>
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<td>12.5</td>
</tr>
<tr>
<td>High QRS voltage</td>
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<td>1.4</td>
</tr>
<tr>
<td>X-rays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic calcification</td>
<td>32</td>
<td>44.4‡</td>
</tr>
<tr>
<td>Mean cardiothoracic ratio</td>
<td>0.497†</td>
<td></td>
</tr>
</tbody>
</table>

* This table shows the total number of persons manifesting each condition, without regard to whether the condition developed before or after blood pressure determination.

† Difference significant at 0.05 level.
‡ Difference significant at 0.01 level.
had intermittent claudication which developed prior to entry.

Diabetes Mellitus

Seven patients in the hypertensive group were given a diagnosis of diabetes mellitus by the time of entry as compared to two in the control group. In the follow-up period 12 hypertensive subjects and five control subjects developed evidence of diabetes mellitus.

Chest X-Rays

Chest x-rays were available to measure cardiothoracic ratio in both members of 53 pairs of subjects. Mean cardiothoracic ratios differed significantly although the magnitude of the difference was small (0.497 for hypertensive patients vs. 0.475 for controls). A larger percentage of patients with systolic hypertension had a ratio greater than 0.5 (52.8% vs. 22.6%). Aortic calcification was found in 32 patients in the systolic hypertensive group and in 16 of the control group. In most instances this was located in the aortic arch.

Electrocardiographic Data

Nine subjects with systolic hypertension and four control subjects were found to have left axis deviation (mean QRS axis less than −30°) and one member of each group had increased QRS voltage (R amplitude in V5 or V6 plus S amplitude in V1 greater than 35 mm).

Mortality

In the systolic hypertensive group, eight people died during the follow-up period. Seven of these were listed as cardiovascular deaths; three were due to myocardial infarction, two were caused by cerebrovascular disease, and two were the result of congestive heart failure. In the control group there were five deaths, only one of which was due to cardiovascular disease (myocardial infarction). The remaining deaths in both groups were due to malignant lesions and chronic pulmonary disease. The difference in number of cardiovascular deaths was statistically significant (P < 0.05).

Discussion

Many observers agree that elevated levels of systolic blood pressure are common in elderly individuals. The relatively low prevalence of systolic hypertension in the Leisure World population was somewhat surprising. This low prevalence may be due in part to the higher cutoff levels used in this study. If only the first blood pressure determination was used, the prevalence of systolic hypertension at Leisure World was 13.9%. The prevalence dropped to less than 3% when the subsequent two blood pressure readings were examined. The extreme lability of systolic hypertension is evidenced by the fact that of the 451 persons who were found to have systolic hypertension on their first visit, 227 persons (50.3%) were excluded because of normal systolic blood pressure readings on one or both of the next two visits.

Long-term studies of large numbers of younger persons initially classified by blood pressure level have made it clear that subsequent morbidity and mortality rates increase as blood pressure level increases over a wide range of observation, without a definite threshold or dividing line between the normal and abnormal. Thus, the choice of 160 mm Hg as a cutoff point for systolic hypertension in the present study should not be interpreted as a biologic threshold level. Some defining level was needed for selecting a study group for medical record review and 160 or over (with a diastolic pressure of less than 90) has been recommended as the criterion for systolic hypertension in the past. Choosing a matched comparison group with systolic blood pressure levels consistently below 140 mm Hg helped to assure a meaningful comparison between groups clearly contrasting in systolic blood pressure. If more detailed analyses on greater numbers of subjects can be undertaken in the future, it is likely that differences between the hypertensive and normotensive groups noted in this study will appear as a continuous gradient according to systolic blood pressure level.

Systolic hypertension has been ascribed to atherosclerotic hardening of the great vessels
and the resulting decrease in vascular elasticity. In addition, Conway\textsuperscript{10} has suggested that there is decreased sensitivity of the baroreceptor mechanisms in atherosclerotic hypertension. Fineberg,\textsuperscript{11} in an autopsy study of systolic hypertension, commented on the marked atherosclerosis of the aorta. The prevalence of aortic knob calcification was twice as great in our subjects with systolic hypertension as compared to the control subjects. However, a high degree of aortic atherosclerosis (at least as indicated by diffuse aortic calcification on x-rays, symptomatic aortic occlusive disease, or aortic aneurysm), was not evident in the systolic hypertensive patients. Unfortunately, no autopsy studies were available on those patients who died.

The possibility of antihypertensive therapy affecting our findings must be considered. Twenty-nine patients in the study group had a positive past history of hypertension at the time of initial examination and of these, 16 were on some form of antihypertensive medication. Two patients with no prior history of hypertension were receiving thiazide diuretics. No patient was receiving a ganglionic blocking agent. None of the control patients were taking any form of medication which could influence blood pressure. Two of the systolic hypertensive patients receiving therapy sustained myocardial infarctions, and one of them died. One person receiving therapy had a stroke, and another subsequently developed angina pectoris. Thus, the small subgroup receiving antihypertensive therapy did not contribute disproportionately to the overall morbidity or mortality. The possibility exists that the patients under therapy also had diastolic hypertension which was being effectively treated.

The difference between the systolic hypertensive group and the control group regarding both the incidence and prevalence of diabetes is impressive. The correlation between systolic hypertension and diabetes mellitus has been observed before. In Fineberg's\textsuperscript{11} series, the prevalence of diabetes in patients with elevated systolic blood pressure was 33% as compared to 23% for patients with diastolic pressure elevation. Miller\textsuperscript{12} noted that the average blood pressure is higher in diabetics and stated that diabetes is associated with an increase in systolic blood pressure.

Although not all comparisons of individual abnormalities were statistically significant, the morbidity and mortality from cardiovascular disease was greater in the hypertensive group. These differences tend to confirm in our elderly population the contention of Gubner\textsuperscript{13} that systolic hypertension is a significant risk factor for the development of cardiovascular disease. However, the causative nature of systolic hypertension is by no means proven by these data. The increased mortality in the systolic hypertensive group may merely reflect a more basic abnormality such as diffuse arteriosclerosis, or it may be related to the other clinical conditions found in this group of patients. These possibilities, however, do not negate the prognostic value of systolic hypertension. It is unfortunate that we are unable to separate the concomitant (and perhaps more critical) features of naturally occurring forms of systolic hypertension from the merely elevated blood pressure. No isolated form of systolic hypertension exists which could demonstrate the effects of the chronically elevated systolic blood pressure itself in the absence of other serious conditions such as diffuse arteriosclerosis, hyperthyroidism, or aortic insufficiency. A possible exception is the hyperkinetic heart syndrome.\textsuperscript{14} This condition is usually found in much younger persons and is thought possibly to be an early abnormality in patients who will eventually develop diastolic hypertension.

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