Mortality article 327L1

F.D.R.'S FATAL STROKE, MORTALITY IN SEVERE HYPERTENSION, 1944-45

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Over 50 years ago, on the afternoon of April 12, 1945, President Franklin D Roosevelt died at Warm Springs, Georgia, about two hours after the onset of a sudden, very severe stroke.[1] Only retired medical directors today are likely old enough to have a personal memory of the tremendous public impact of FDR's death on all of the nations engaged in the titanic struggle of World War II. American, British and Russian armies were closing in on Berlin, and the remnants of Germany were still desperately defended by Hitler and the Nazi forces. Hitler's suicide soon followed, then the surrender of all German armed forces in early May, and this global war was over in the European theater.

As vice president, Harry Truman had never ever been briefed by Roosevelt, any of his aides, or any member of the cabinet or the joint chiefs of staff, on the conduct of the war, foreign relations, or the Manhattan Project (for construction of the atomic bomb, still a closely guarded secret). Although he never attended college, Truman brought many valuable personal attributes to help him face the immense responsiblities he inherited on Roosevelt's sudden death: personal integrity and optimism, a lifelong habit of omnivorous reading with a keen interest in history, experience as a captain of an artillery battery in World War I (with a record of exceptional leadership), administrative experience at the county level, and political experience as a respected senator. Truman would prove equal to the arduous task of leading his country through the remaining months of World War II, then through the innumerable problems arising in the post-war era.

Although Roosevelt's death was sudden, it cannot be regarded as totally unexpected, and certainly wasn't to the physicians responsible for his medical care.[1,2] Fifty years ago the health of the president was still regarded as a private affair, not a matter for public disclosure. However, following a prolonged period of upper respiratory infection and bronchitis in early 1944, the president's personal physician and surgeon general of the Navy, Vice Admiral McIntire, persuaded Roosevelt to have an outpatient checkup at the National Naval Medical Center, just outside Washington. Our only detailed source of medical information on the president's condition from March 27, 1944 up to the time of his death is found in an article by his attending cardiologist, Dr. Howard G Bruenn, titled "Clinical Notes on the Illness and Death of President Franklin D Roosevelt," published in 1970 in the *Annals of Internal Medicine*, 25 years after Roosevelt's death.[2]

In the article Dr. Bruenn stated that he had written the article from personal notes of his, because no other information was available and the complete medical record on the president, kept in a hospital safe, could not be located after his death. Dr. Bruenn at that time was a Naval Reserve medical officer, the consulting cardiologist of the Medical Center Hospital and chief of its ECG laboratory. Dr. Bruenn conducted the cardiac evaluation of Roosevelt in the hospital, made recommendations for treatment, and continued to supervise this aspect of his care, seeing him at least three times per week when the president was in Washington, and daily when he accompanied the president on all of his trips, including the one to Yalta. He was the first physician to see the president after his fatal stroke, and was the physician who pronounced the president dead.

Before I summarize Dr. Bruenn's article, I should mention that rumors of the president's ill health, circulating since his second term, intensified in 1944-1945, because of his increasingly haggard appearance in most of the still and motion pictures made of him during this period. It was noted privately by associates and others who came in contact with him that Henry Wallace, Roosevelt's vice president, was considered a political liability by the president's political advisers, who persuaded Roosevelt to find a different running mate for the 1944 election campaign. Roosevelt agreed in principle; Wallace was eased out as the nominee; but Roosevelt was maddeningly noncommittal in supporting Truman as his vice presidential running mate until the last possible moment before Truman's name had to be placed in nomination at the July Democratic National Convention.

We can only speculate if concern about a possible premature death of Roosevelt during his fourth term may have been part of the motivation of the political advisers in finding a more "reliable" candidate for vice president than they viewed Wallace being. Wallace's subsequent split with Truman's administration over foreign policy and his campaign against both Truman and Dewey, as candidate of the short-lived Progressive Party in 1948, prove that his completely unrealistic views of the Soviet Union would have constituted a disaster for the US and all Western nations if he, instead of Truman, had succeeded to the presidency after Roosevelt's death.

Dr. Bruenn's findings at the end of March, 1944 may be summarized as follows. At examination March 27, Roosevelt appeared

tired and his face was gray. His activity was limited from the post-polio complete paralysis of both legs (present since 1921), but such movement as he was capable of, caused breathlessness. A cough was present, with sonorous and sibilant rales. The heart was enlarged to examination, with a blowing systolic murmur at the apex, and both aortic and pulmonic second sounds were accentuated. Pulse rate was 72 per minute and regular. Blood pressure was 186/108, and the hospital chart showed readings of 136/78 in 1935, 162/98 in 1937, 178/88 in 1940 and 188/105 in February 1941. Eyegrounds showed A-V nicking, but no exudates or hemorrhages. The ECG showed nearly 2-mm inversion of the T wave in lead one, and 7-mm inversion in CF4, the only chest lead taken. The chest X-ray showed left ventricular enlargement of the heart, a tortuous and dilated aorta, and engorgement of the pulmonary vessels; on fluoroscopy, left ventricular contractility was reduced. The urine showed 1+ albuminuria and numerous casts. Dr. Bruenn's diagnoses were hypertension, hypertensive heart disease, left ventricular heart failure and acute bronchitis.

These findings led to numerous medical conferences involving Dr. Bruenn, Dr. McIntire, other Navy physicians and two prominent civilian physicians. Numerous blood pressure readings confirmed the hypertension, with a maximum reading of 230/126 and an average of 206/118. Because of the president's wartime responsibilities it was not possible to provide for a period of complete bed rest, but digitalization did eliminate the signs of heart failure and brought the T waves back to normal in the standard leads and in six CF chest leads. A regimen was established that did provide for more rest, a reduced schedule and some working "vacations," that did seem to benefit the president's condition some of the time. The blood pressure, however, continued to remain very high, with the systolic reading generally over 200 and the diastolic generally over 110. The diastolic range was from 90 to 130 mm, the lower readings generally found in the afternoon when Roosevelt was away from the White House, visiting or on shipboard.

Of course, in 1944-1945 there were *no* antihypertensive drugs available, and there was no specific treatment his physicians could undertake to control the hypertension of the president during his election campaign and the climax of a global war. It must have been a frustrating experience, which came to an end after the president experienced, without premonitory symptoms, an extremely severe stroke while he was sitting for a portrait at at his Warm Springs retreat. The blood pressure taken by Dr. Bruenn 15 minutes after onset, with the president unconscious, yielded a systolic reading in excess of 300 mm (above the upper limit of the manometer) and a diastolic reading of 190 mm. The president stopped breathing and was pronounced dead about two hours after the onset of the stroke. The official medical comment was that the stroke was completely unexpected, and nothing was said about the hypertension, which had appeared initially in 1937, and had been severe, with symptomatic hypertensive heart disease for over a year.

Medical significance of hypertension in 1944

Despite the lack of antihypertensive drugs, physicians in World War II were well aware of the adverse prognostic significance of severe hypertension, especially with complications or the findings of malignant hypertension. It was fully reconized that several types of secondary hypertension must be differentiated from the great majority of cases of essential hypertension. The importance of vascular abnormalities in the eyegrounds was also appreciated, in addition to complications such as cardiac enlargement, congestive heart failure, protein, red cells and casts in the urine, and the development of azotemia. The relation of stroke as a feared complication of severe blood pressure elevation was also well known. The accelerated downhill course of malignant hypertension had been well documented.

The above statements are based on my memory of the state of medical knowledge of hypertension and of the medical literature during medical school and internship and clinical expereience that followed. None of this is discussed in Dr. Bruenn's article, but I am confident that textbooks of medicine of that era will confirm what I have written just above. Mortality follow-up studies were much less available in the medical literature prior to 1944 than they have become in more recent decades. Studies of mortality in severe hypertension do exist for that approximate time period. but before I examine the effect of these severity factors I will document the excess mortality trends associated with the basic epidemiologic factors of age, duration of follow-up, and sex. For this purpose I will utilize hitherto unpublished data for exposure and excess death rates from the *1979 Blood Pressure Study.*

Substandard experience of hypertensive subjects

Tables 327L1-1 and 327L1-2 display these comparative mortality results, in the first table by age, duration and sex, and in the second by blood pressure classification and sex. Despite the heavy weighting of blood pressures in the borderline hypertensive range, this insurance experience has been chosen because of its large volume. In addition, I desired to make these data available for the first time to readers of the *Journal of Insurance Medicine.* In 1986 I prepared a summary of a portion of these data (male only), for publication in this journal[3,4] and the article with its tables has been reprinted in the *1994 Medical Risks,* Volume Five, Table 327L1-1 includes five of the six detailed age groups in the study, instead of the broad age groups, 15 to 39 and 40 to 69 years, used in 1986 (deaths were too few in the youngest age group, 15 to 19 years, to warrant inclusion of these results). The reason for omitting exposure and EDR data from the *1979 Blood Pressure Study* was the extremely large volume of the results actually shown in the tables: observed and expected deaths, and mortality ratios. However, the database for the study remains in the custody of John R Avery, director of CMAS in the MIB, who was responsible for the data processing, and supplied the detailed printouts of the separate standard and

substandard experience in 1986, with the exposure and EDR data included.[1]

Excess mortality, measured as EDR, shows a consistent pattern of increase with advancing age and increase in follow-up duration to the interval 15 to 22 years. In men the age increase in EDR was from 0.6 per 1,000 per year in age group 20 to 29 years to 11.1 per 1,000 in the oldest age group, 60 to 69 years. In women the increase over the same age range was from 1.7 to 3.6 per 1,000. From the first to the last duration interval, EDR increased from 1.9 to 17.3 per 1,000 in men and from 0.9 to 9.0 per 1,000 in women. Excess mortality as EDR is consistently higher in men than in women, with the single exception of women under 40 years. The apparent reversal by sex in the youngest age group, 20 to 29 years, is probably a random variation, because only nine deaths were observed in this female age group: the apparent increase in mortality rate, female over male, is not statistically significant, even at the 90 percent confidence level. In age group 30 to 39 years, the EDR values are almost identical in women as compared with men, that is, there is no significant reversal when the number of female deaths is much larger.

As I explained in the 1986 article,[3] the blood pressure groups A through F comprise a graded increase in both systolic and dias-

Table 327L1-1

Unpublished data, 1979 Blood Pressure Study– mortality by sex, age, and duration for all policies rated for hypertension alone

Group	Exposure policy-years.	Number of death claims observed	Number of death claims expected*	Mortality ratio	Mean ann. mort. rate per 1,000 observed	Mean ann. mort. rate per 1,000 expected	Mean ann. mort. rate per 1,000 excess
	E	d	d'	%	q	q'	(q-q')
Age		*Rated men with and without minor impairments*					
20-29 years	107,204	159	92.5	172	1.5	0.9	0.6
30-39	269,110	1,182	494.2	239	4.4	1.8	2.6
40-49	429,514	4,221	1,943.2	217	9.8	4.5	5.3
50-59	246,611	4,301	2340.5	184	17.4	9.5	7.9
60-69	45,207	1,358	856.6	158	30.6	18.9	11.1
		Rated women with and without minor impairments					
20-29 years	3,774	9	2.7	333	2.4	0.7	1.7
30-39	14,699	61	21.0	290	4.1	1.4	2.7
40-49	88,653	505	248.0	204	5.7	2.8	2.9
50-59	89,981	735	446.7	165	8.2	5.0	3.2
60-69	26,531	401	304.5	132	15.1	11.5	3.6
Duration		*Rated men with and without minor impairments*					
0-2 years	344,940	1,398	736.7	190	4.0	2.1	1.9
2-5	340,454	2,888	1,471.2	196	8.5	4.3	4.2
5-10	295,590	4,028	2,036.9	198	13.6	6.9	6.7
10-15	95,300	1,998	1,029.1	194	21.0	10.8	10.2
15-22	26,594	918	459.4	200	34.5	17.2	17.3
All	1,103,198	11,230	5,732.4	196	10.8	5.8	5.0
		Rated women with and without minor impairments					
0-2 years	68,598	203	106.9	190	1.9	1.0	0.9
2-5	69,168	409	238.6	158	5.9	3.7	2.2
5-10	60,187	641	356.9	180	10.6	5.9	4.7
10-15	20,253	311	205.7	151	15.4	10.2	5.2
15-22	6,789	147	95.1	154	25.4	16.4	9.0
All	223,995	1,711	1,023.2	167	7.6	4.5	3.1

* Basis of expected deaths: 1954-1972 intercompany select and ultimate tables

tolic presure from the lower range of normal to the highest combination in hypertension, 168+/98+, a relatively mild degree of hypertension by clinical standards. The reason for rating for hypertension in the two normotension groups, A and B, is the history of hypertension, treated or untreated, that could not be ignored in the underwriting of the application, despite the normal blood pressure readings on examination and any rechecks obtained. The experience is much smaller in groups A and B than in the groups of borderline hypertension, C and D (Table 327L1-2), because random or post-treatment reduction of blood pressure to below 138/83 in not common in hypertensive insurance applicants. In this article I have abandoned the distinction I used to make between "elevated blood pressure" and "hypertension," because of the much wider recognition now of the true prognostic significance of borderline hypertension, thanks to the success of the National High Blood Pressure Detection and Education Program. Group G includes cases of systolic hypertension, and group H, cases of diastolic hypertension; data are also given for all other policies rated for hypertension not in the blood pressure combinations for groups A through H, and for the total so rated, the experience for which shows 11,230 death claims for male policyholders and 1,711 for female policyholders.

As would be anticipated, the EDR increases steadily with blood pressure group from A-B through F, with overal mortality higher in men, EDR 5.0 per 1,000 per year, than in women, 3.1 per 1,000. There are two exceptions: EDR in women is slightly higher in group A-B than in group C, and again slightly higher in group

Table 327L1-2

Unpublished data, 1979 blood pressure study– mortality by sex and blood pressure class, all issued policies rated for hypertension

*Class of pressure**	*Distribution of exposure*	*Exposure policy-yrs.*	*Number of death claims observed*	*Number of death claims expected***	*Mortality ratio*	*Mean ann. mort. rate per 1000 observed*	*Mean ann. mort. rate per 1000 expected*	*Mean ann. mort. rate per 1000 excess*
	Percent	*E*	*d*	*d'*	*Percent*	*q*	*q'*	*(q-q')*
			Rated men with and without minor impairments					
A+B	8.0	87,168	596	315.3	189	6.8	3.6	3.2
C	19.2	212,247	1,694	911.4	184	8.0	4.3	3.7
D	16.7	184,680	2,218	1,142.3	194	12.0	6.2	5.8
E	5.1	56,054	848	368.2	230	15.1	6.6	8.5
F	2.3	25,793	432	157.5	274	16.8	6.1	10.7
G	12.4	136,582	1,648	896.8	184	12.1	6.6	5.5
H	11.1	122,415	995	530.4	188	8.1	4.3	3.8
All other	25.2	278,759	2,799	1,410.5	198	10.1	5.1	5.0
Rated total	100.0	1,103,198	11,230	5,732.6	196	10.2	5.2	5.0
			Rated women with and without minor impairments					
A+B	6.8	15,138	73	45.2	162	4.8	3.0	1.8
C	11.8	26,432	131	96.1	136	4.9	3.6	1.3
D	20.0	44,868	334	215.8	155	7.4	4.8	2.6
E	7.9	17,647	161	80.0	201	9.1	4.5	4.6
F	4.9	10,977	86	40.4	213	7.8	3.7	4.1
G	15.9	35,645	340	214.0	151	9.5	6.0	3.5
H	6.9	15,456	103	53.4	193	6.7	3.5	3.2
All other	25.8	57,832	483	218.2	174	8.4	4.8	3.6
Rated total	100.0	223,995	1,711	1,023.2	167	7.6	4.5	3.1

* Definition of blood pressure classes see 1979 Blood Pressure Study, compiled and published by the Society of Actuaries and the Association of Life Insurance Medical Directors of America, 1980. See also references three and four.

A *Under 128/under 83*
B 128-137/78-87
C 138-147/83-92
D 148-157/88-97
E 158-167/93-102
F 168 up/98 up
G 148-167/78-87
H 128-147/93-102

** Basis of expected deaths:1954-1976 intercompany standard select and ultimate tables.

E than in group F. For both sexes EDR is significantly higher in systolic than in diastolic hypertension (groups G and H, respectively, in Table 327L1-2). All other rated policyholders not in groups A-H have an excess mortality close to the average for all policy-holders rated for hypertension. The mortality ratio is 196 percent in men and 167 percent in women. The prevalence in terms of exposure of the policies rated for hypertension shows that about 75 percent of policies are included in groups A-H, with the normotensive groups having the smallest number, and the borderline hypertensives the largest number. Policies in groups G and H outnumber those with definite combined systolic and diastolic hypertension by a wide margin.

In both of these tables from the substandard issues in the *1979 Blood Pressure Study* I have provided columns of data for both q and q', the observed and expected mean mortality rates per 1,000 per year, data not included in 1986 summary tables.[5] These rates deseve careful attention in their relation to both EDR and the mortality ratio, MR. The magnitude of q' is dependent on mean attained age throughout the period of exposure in each age, duration, or blood pressure group. Expected mortality does increase, of course, by age and duration, but differences also appear in the blood pressure groups, indicative of a definite trend for higher blood pressure levels to be found in progressively older policyholders.

In Table 327L1-2 the lowest q' values were found in the normotensive groups, and the highest in group G, those with systolic hypertension. The disparity in q' between men and women is relatively small, implying an older average age for the women, which is confirmed in the age data in Table 327L1-1 and in other hypertension studies in which age distribution and mean age are given. A study of MR values in relation to age, duration, and blood pressure shows patterns of variation that are irregular, nearly constant, or decreasing. This demonstrates clearly the limitation of of the MR as an index of excess mortality in groups with differing mean age or mean duration. In the published Blood Pressure Study the only index available is the mortality ratio, MR. In these comparative mortality results in hypertension we again find convincing evidence of the excess death rate, EDR, as a more reliable index of patterns of excess mortality over a wide range of attained age and between male and female subjects.

The overall EDR values for men and women rated for hypertension in the *1979 Blood Pressure Study* in the range of borderline rather than definite hypertension, certainly not a severe degree of hypertension. Do these patterns also prevail in hypertensive patients when the blood pressure is considerably higher (as it was in the case of President Roosevelt), in the presence or absence of complications? The mortality patterns are, indeed, similar, as shown in older studies such as those reported in the abstracts, or in the Chapter Eight text of the *1976 Medical Risks* monograph.[6] Abstract 323 presents results of a 20-year follow-up of patients with essential hypertension diagnosed at the Mayo Clinic in 1940; these show the same increase of EDR with duration, and increase in EDR to above 400 per 1,000 per year in men with grade four severity (papilledema in the eyegrounds).[7]

In Abstract 326 results are detailed for applicants to the New York Life, 1946 to 1950, who had a systolic pressure of 162 mm or higher, or a diastolic of 92 mm or higher.[8] This differed from the usual insurance mortality study, because it was done on individual applicants, not policies, and declined applicants were traced as well as those to whom a policy was issued. The pattern of increasing EDR was observed in four male and three female age groups, and in up to eight blood pressure classes, for all durations combined to 1956. All but 48 of 3,263 applicants were successfully traced, and the highest EDR, in men age 60 to 69 years with blood pressue 178/118 mm or higher, was 118 per 1,000 per year. Abridged results are given for additional studies of patients with moderate to severe hypertension, most untreated, but some treated with anti-hypertensive drugs, in Tables 8-5 and 8-7 of the *1976 Medical Risks* volume. The 1953 report by Palmer and Muench gives annual mortality rates by detailed combinations of age, duration and severity of hypertension,[9] also with mortality ratios and survival data. Mortality increase with age is also demonstrated in the hypertension study, below.

MORTALITY IN A HYPERTENSION OUTPATIENT CLINIC 1946 TO 1953

For a detailed consideration of mortality in essential hypertension in patients not treated with antihypertensive drugs I will use the results of a single study, that of Sokolow and Perloff.[10] This report is of great value because of the attention given to describing all important aspects of a follow-up study: selection of the series, age, sex, severity, complications, and completeness of follow-up. Patients were selected for study at the hypertension clinic of the University of California School of Medicine in San Francisco during 1946 to 1953 if they had sustained blood pressure of 150/90 mm or more. Excluded from this essential hypertension series of 143 men and 296 women were all cases of secondary hypertension, treatment by sympathectomy, adrenalectomy or ganglion-blocking drugs, age 70 years and up, and loss before a minimum of five years follow-up for survivors. Patients were characterized by a combination of sex, age group and one of four defined classes of initial severity. The total series was also classified by blood pressure, transverse heart diameter (by the Clark-Ungerleider tables), pattern of left ventricular hypertrophy (LVH) in the ECG, eyeground vascular abnormalities (Keith-Wagener classification), cardiac status, renal status, and cerebrovascular status, with data on paired combinations of these variables. The age/sex distribution for the total series and data for expected mortality rates are shown in Table 327L1-3, and distributions for some of the severity classes are shown in Table 327L1-5.

Before I get into a discussion of these distributions I should note that Sokolow presented a summary of this mortality study at the 1962 meeting of the Medical Section of the American Life Convention, with additional material on early results from use of the

semi-automatic portable blood pressure manometer (the portameter), and age variations in blood pressure in the population. In addition, Kita has presented to readers of the *JIM* a table of annual mortality data for men and women in this study, all ages and severities combined, with a discussion of hypertension in this period and the methodology of his life table preparation. Results in the present article concentrate on mortality differences due to severity, in terms of mean annual rates over the five-year follow-up period.

Fully two thirds of the hypertensive patients in this series were women in sharp contrast to the preponderance of the male sex in coronary heart disease. As evident in Table 327L1-3, this higher prevalence of women is present in all age groups. The largest age group was for those 40 to 49 years; the number of patients age 10 to 19 years was so small I have included them with patients 20 to 29 years, in age group <30 years. Mean ages are also given, overall in Table 327L1-4, and for the initial severity groups in Table 327L1-5. With respect to blood pressure, fewer than 20 percent of these patients with essential hypertension were in the most severe class III, with an initial near-basal blood pressure reading higher than 250/130 mm. Most of the patients were divided about equally between class I, 150-200/90-120 mm, and class II, 200-250/120-130 mm.

Although Roosevelt's diastolic readings were not consistently over 120 mm, I would place his hypertension in class II. The largest group for other classifications in this table were class II for highest initial severity class, class II for eyeground findings (arterial abnormalities without hemorrhages, exudates or papilledema), but the normal class I for heart diameter (not exceeding 10 percent above predicted). Heart diameter over 10 percent was a powerful predictor of progressively increased EDR in classes II through IV. Definite LVH, any congestive heart failure, coronary heart disease or cerbrovacular disease, and abnormal renal function, not shown in the table, were all associated with higher excess mortality. For most of these factors the prevalence in high-severity groups was low in this outpatient series, which should give a more representative cross-section of hypertensive persons in the general population than any series of hospitalized patients.

Expected mortality

The US 1949 to 1951 Life Tables for the total population were used to derive expected mortality rates, all ages combined. These computations are shown in the middle of Table 327L1-3 for first year mortality, and in the right-hand portion of the table for the survivors at the end of five years (at age x+5 instead of age x). The five-year survival rates are given by the authors by age group only for male and female combined. It has been necessary to allocate number of survivors, s, by sex in such a way that totals are reconciled for each age group, and for the total male and total female patients. Expected rates, q', are therefore exact for all ages combined, by sex and by total, for the first year, but only an approximation for the sixth year. Nevertheless, limitations on the error in the assumed values of s by sex in each age group are set by their interdependence and by the progression of the observed survival rate, both sexes combined. As a consequence, I consider the appoximations for overall mean q', male, female, and total, at age x+5 years to be good approximations.

Table 327L1-4 demonstrates two extremely important characteristics of mean q', all ages combined, when the range of age is a wide one, as it is in this series. The first point is that the tabular age corresponding to the observed mean q', male or female, is invariably higher than the actual mean age, x. For men the tabular mean age is 4.5 years higher than the actual mean age of 45.5 year; for women the actual mean age is 46.7 years, and the tabular age is 51.0 years, or 4.3 years higher. This is why using the mean age to enter the life table for an expected mortality rate will always underestimate the true mean q'. For example, if we enter the life table for the total male population at the mean age of 45.5 years, we obtain a rate of 0.0073, which would underestimate the true mean q' of 0.0109 by 33 percent!

The second important characteristic demonstrated in the table concerns the progression of mean age and mean q' with duration of follow-up. The mean age of the male survivors at age x+5 is not 45.5+5.0=50.5, but only 47.4 years. Even though each individual survivor is, indeed, five years older, the age distribution shifts in favor of the younger entrants, and after five years of follow-up the mean age of the men has increased only 1.9 years to age 47.4, and the mean age of the women has increased only 3.9 years to age 50.6. The smaller increase in mean age produces a corresponding impact in a smaller than anticipated increase in mean q' over the five years of follow-up. If all of the men had been 50.0 years old on entry (the tabular mean age), q' would have increased from 0.0109 to 0.0169 after five years and reaching attained age 55.0 years. This change in annual mortality rate would be an increase by a factor of 0.0169/0.0109=1.550 for five years, or an annual factor of 1.092 (9.2 percent increase), as a "geometric mean."

However, as the table shows, that actual increase in mean q' over five years was a factor of 1.183, a much smaller annual increase of 3.4 percent than the 9.2 percent anticipated from age 50 to age 55 in the total male population. The same phenomenon is observed in the hypertensive women, although their actual rate of increase in q' is closer to the anticipated tabular increase than in the case of hypertensive men (the anticipated tabular increase for women from age 51 to age 56 years is 8.1 percent per year). The progression of q' with duration is variable from one series to another and is dependent on the initial age distribution and the pattern of observed mortality by age group. If the mortality data are not reported by age group, one can only make a rough approximation of the progression of q', all ages combined. It is even possible for the inital change in mean age and mean q' to be a decrease instead of a small increase. This is true, for example, in thyroid cancer, as I used to show in the mortality seminars more than 10 years ago. It is also true in patients on dialysis because of end-stage renal disease (see Abstract 637M1 in Vol. 27, No. 1 (Summer 1995) of *JIM*). One reason for my concentration on this par-

ticular follow-up study of hypertension is the fact that the authors did report five-year mortality by age group for the total series (in their Table 15), from which I derived the numbers of survivors, s, in Table 327L1-3.

Mortality by severity/complication of hypertension

The univariate excess mortality in this series, all ages, male and female combined, is shown in Table 327L1-5 for the principal severity and complcation clases of initial severity (I to IV), blood pressure level (I to III), eyeground vascular changes (I to IV), and transverse heart diameter (I to IV), as a quantitative measure of heart enlargement. Values of q' in classes I to IV of initial severity are accurately calculated from the initial age/sex distribution given for each class. In the other classification groups q' has been adjusted from the series mean q' in accordance with the progression by initial severity (note the values of mean age), on the assumption that mean age tends to increase with severity in each classification. Both observed and expected mean annual mortality rates are "geometric means," derived from the complement of the annual survival rate as a geometric mean of the five-year survival rate. Since there were no withdrawals during the complete five-year follow-up, the life table cumulative survival rate, P, is given directly as the quotient, s/ℓ (the "ad hoc" survival rate). Excess mortality will be described in terms of EDR rather than mortality ratio.

The minimum EDR, in class I of several of the factors, was about 15 extra deaths per 1,000 per year. In the class IV heart size (diameter >.30 percent of predicted) there were no five-year survivors out of 26 entrants. If one assumes a five-year survival rate of 0.0005, the EDR is of the order of 770 per 1,000 per year, the highest of any of the severity classifications. Other classified groups of maximum severity yielded annual EDR values per 1,000 of 307 for initial severity, 192 for highest blood pressure, and 263 for patients with papilledema in their eygrounds. None of the miscellaneous risk factors showed excess mortality as high as that in class IV heart enlargement. Annual EDR per 1,000 was 207 in the two most severe classes of LVH pattern, 241 in patients with evidence of heart failure, 276 in those with impaired renal function, only 117 in those with coronary heart

Table 327L1-3

Age and sex distribution of hypertension clinic outpatients, 1946-53, on entry and after complete five-year follow-up, with expected mortality data

Entry age	*Sex M or F*	*No. of entrants*	*Distribution factor*	*Expected mort. rate**	*Expected deaths*	*5-year survivors***	*Distribution factor*	*Expected mort. rate**	*Expected deaths*
Years		ℓ	f	q'_x	d'	s	f	q'_{x+5}	d'
<30	M	13	52%	.0020	0.026	11	50%	.0021	0.023
	F	12	48%	.0011	0.012	11	50%	.0014	0.015
	M+F	25	5.7	.0016	0.038	22	7.9	.0017	0.038
30-39	M	26	26%	.0029	0.075	14	20%	.0044	0.062
	F	74	74%	.0020	0.148	57	80%	.0030	0.171
	M+F	100	22.8	.0022	0.223	71	25.5	.0033	0.233
40-49	M	58	36%	.0070	0.406	25	24%	.0110	0.275
	F	104	64%	.0045	0.468	78	76%	.0066	0.515
	M+F	162	36.9	.0053	0.874	103	37.1	.0077	0.790
50-59	M	31	32%	.0169	0.524	11	21%	.0248	0.273
	F	65	68%	.0097	0.630	42	79%	.0146	0.613
	M+F	96	21.9	.0120	1.154	53	19.8	.0167	0.886
60-69	M	15	28%	.0353	0.530	4	14%	.0507	0.203
	F	41	72%	.0218	0.850	25	86%	.0348	0.870
	M+F	56	12.3	.0256	1.380	29	9.7	.0370	1.073
Total	M	143	33%	.0109	1.561	65	23%	.0129	0.836
	F	296	67%	.0071	2.108	213	77%	.0103	2.184
	M+F	439	100.0	.0084	3.669	278	100.0	.0109	3.020

* Basis of expected mortality: 1949 to 1951 US population rates for total male and total female

** Observed data from reference nine, for subtotals of survivors in each age group, and males, females and total, all ages

Numbers of male and female survivors by sex in each age group are estimated from known survival rates, so that subtotal and total numbers are reconciled. See text.

disease (angina and MI combined), and only 124 in those with a history of stroke.

Mortality estimated for FDR

President Roosevelt was 62 years of age prior to his death. His hypertension would have placed him in the class II blood pressure of Sokolow and Perloff, and his vascular changes in a class II eyeground category. We do not have any quantitative estimate of relative heart diameter, but we do know that there was considerable left ventricular enlargement in the chest X-ray, and impaired ventricular function on fluoroscopy. In addition there was probable congestive heat failure present prior to digitalization, and the initial ECG showed inverted or diphasic T waves, probably part of an LVH pattern fitting into class III or IV. Roosevelt thus had multiple complications of his hypertension that fit into a class II to IV as used in this study. In the presence of these multiple complication factors for the hypertension, can we improve on the univariate mortality results in Table 327L1-5? We can, because of the additional tables in our key article, tables that present mortality data in the form of a matrix, with each of the major classifications at the top subdivided according to the other classes arranged vertically. Another reason for my devoting so much time to this very old but very well presented mortality study!

Table 327L1-6 contains three sets of data with class II blood pressure as the "senior partner" of the combination. The top set of data shows that class II eyeground abnormalities have no unfavorable impact on excess mortality. In fact, of the four possible combinations of classes I and II for both blood pressure and eyeground findings, this EDR is the lowest, and lower than the aggregate EDR of 45 per 1,000 for all four combinations, which include 313 entrants, 71 percent of the total, a fraction that obviously has a better prognosis than the remaining 29 percent of the total. Common sense tells us that there must be some hidden bias of a favorable nature in the combination shown in the table. The combination of blood pressure class II and eyeground class II is of no assistance in helping us to evaluate Roosevelt's mortality due to his hypertension and associated findings.

We can do much better, I believe, using the combination of blood pressure class II and either heart size classes II+III or LVH pattern, class III+IV. I have combined heart size classes II and III because we do not know the degree of enlargement by the Clark-Ungerleider tables. This combination, based on 53 entrants and 33 deaths, gives an EDR of 165 per 1,000 per year. We have already seen from Table 327L1-5 that increase in heart diameter above 10 percent of predicted is a progressive and very potent predictor increasing mortality. A similar EDR of 172 per 1,000 was found in 47 entrants with blood pressure class II and a combination of two small classes of LVH pattern, III and IV (diphasic and inverted T waves).

In evaluating this EDR level of about 170 per 1,000 we must recognize that it applies to patients of all ages in a series in which women predominated over men. But Roosevelt was a male patient in the age group 60 to 69 years. We have already seen that in hypertension EDR increases with age and is higher in males than in females. Is there any way to adjust this EDR for age and sex?

We can approach this adjustment by an examination of the comparative mortality by age group, men and women combined, and mortality by sex, all ages combined, as shown in Table 327L1-7. The pattern of EDR is one of increase with advancing age in this series of patients with mostly severe hypertension, as it is in other series, including that of the *1979 Blood Pressure Study*, previously described. EDR is very low at 18 per 1,000 in the patients under age 30 years (only three deaths in 25 entrants), and increases progressively to 97 per 1,000 at age 50 to 59 years. The mean annual mortality rate for patients age 60 to 69 years, 123 per 1,000, is the highest observed, but with concomitant increase in expected mortality, the EDR of 89 per 1,000 is slightly smaller than for the age group 50 to 59 years. The EDR for patients age 60 to 69 years, both sexes combined, exceeds the overall EDR by 11 per 1,000.

When all ages are combined, excess mortality is much higher in men than in women, EDR 146 as compared to only 64 per 1,000.

Table 327L1-4

Mean age, tabular age for mean q', and 5-year progression of mean q' by sex, all ages combined, hypertension clinic outpatients 1946-53

Sex M or F	Entry mean age actual	Entry mean age tabular*	Mean age after 5 years actual	Mean age after 5 years tabular*	Mean q' entry	Mean q' after 5 years	Ratio q'_x to q'_{x+5} 5-year	Ratio q'_x to q'_{x+5} annual**
	x	tab x	x	tab x	q'_x	q'_{x+5}	q'_{x+5}/q'_x	Geom. mean
M	45.5y	50.0y	47.4y	51.9y	.0109	.0129	1.183	1.034
F	46.7	51.0	50.6	55.7	.0071	.0103	1.451	1.077
M+F	46.3	—	49.9	—	.0084	.0109	1.298	1.053

* Tabular age in 1949-1951 US life tables, total males or total females corresponding to the observed mean q' rate

** Mean annual increase in q' = $(q'_{x+5}/q'_x)^{1/5}$. From age 35 to 85 years this increase in the population life tables is about 1.09 to 1.10 per year.

Previous results by severity class have been given for all ages and both sexes combined, for whom the overall EDR is 78 per 1,000 per year. The difference between the male EDR and the overall EDR is 146-78=68 per 1,000. The combined adjustment for age and sex, if it is calculated in this manner, is thus an EDR of 11+68, or 79 extra deaths per 1,000 per year. The EDR if class II blood pressure is combined with either increased heart size or the T wave inversion of an LVH pattern in the ECG has been shown to be approximately 170 per 1,000. Perhaps the absence of hemorrhages, exudates and pailledema may be favorable enough to offset any additional "debits" for the early congestive failure (which was improved after digitalization), and a total EDR of 250 per 1,000 would be the most reasonable approximation we could make for agoup of men age 60 to 69 years with the degree of hypertension and the associated findings described by Dr. Bruenn on President Roosevelt in 1944. If we convert the EDR to a first-year motality rate by adding on the expected rate of 44 per 1,000 per and convert to an annual survival rate, we can project a four-year survival rate (the length of the presidential term of office) of roughly 24 percent, If a major reason for the efforts of Rossevelt's political aides to "dump" Wallace as vice president was concern over possible death of Roosevelt while

Table 327L1-5

Severe hypertension in clinic outpatients, 1946-53, comparative mortality by severity or complication (all ages, males and females combined)

Characteristic	*No. of entrants*	*Fraction of total*	*No. survivors after 5 years*	*Surv. rate at 5 years*	*Mean ann. mort. rate per 1,000* observed	expected*	excess	*Mortality ratio*
(Mean age, years)	*ℓ*	*f*	*s*	*P*	*q*	*q'*	*(q-q')*	*Percent*
			Initial severity class					
Class I x=44.6	81	.185	72	.889	23	8	15	285
Class II x=45.1	176	.401	140	.795	45	8	37	560
Class III x=47.5	106	.241	54	.509	126	11	115	1,150
Class IV x=48.9	76	.173	12	.158	319	12	307	2,700
Total x=46.3	439	1.000	278	.633	87	9	78	965
			Blood pressure					
I 150-200/90-120	190	.434	152	.800	24	8	16	300
II 200-250/120-130	176	.402	102	.580	103	10	93	1,030
III >250/130	72	.164	23	.319	204	12	192	1,700
			Eyegrounds (Keith-Wagener class)					
I Normal	139	.323	116	.835	36	8	28	450
II Arterial abn.	217	.505	141	.650	83	9	74	920
III Hemor./Exudates	49	.114	11	.224	258	11	247	2,300
IV Papilledema	25	.058	5	.200	275	12	263	2,300
			Heart size in X-ray (Clark-Ungerleider)					
I Diam. <10% pred.	270	.641	212	.785	47	9	38	520
II 11-20%	101	.240	51	.505	128	10	118	1,280
III 21-30%	24	.057	8	.333	197	12	185	1,640
IV >30%	26	.062	0	<.0005	780±	12	770±	6,500
			Other high risk factors					
III+IV LVH in ECG	102		30	.294	217	10	207	2,200
Cong. heart failure	43		10	.263	253	12	241	2,100
Cor. heart dis.	46		23	.500	129	12	117	1,030
Imp. renal function	65		18	.277	224	12	212	1,880
Stroke	50		24	.480	136	12	124	1,130

Table 327L1-6

Severe hypertension, clinic outpatients 1946-53, comparative mortality by combination of blood pressure and selected complication

*Combination**	*No. alive at start*	*No. 5-year survivors*	*Surv. rate at 5-years*	*Mean ann. mort. rate per 1,000*		
				observed	*expected***	*excess*
	ℓ	*s*	*P*	*q*	*q'*	*(q-q')*
BPII + eyeground II	71	63	.887	24	9	15
BPII + Heart size II and III	53	20	.377	177	12	165
BPII + LVH pattern III and IV	47	17	.362	184	12	172

* BPII- blood pressure 200-250/120-130 mm. Eyegound II– arterial abnormalities only. Heart size II and III– heart diameter in chest X-ray 10 to 30 percent above predicted by Clark-Ungerleider tables. LVHIII and LVHIV- diphasic or inverted T waves in LVH pattern of ECG
** Basis of expected mortality: 1949-51 US life tables, rates for total males and total females

in office, 1945 to 1949, these results on excess mortality in hypertension demonstrate that such intuitive concern was abundantly justified by the statistics of the appropriate life table, at which we have finally arrived, after a lengthy journey.

COMMENT

The reader is referred to Kita's excellent discussion of material drawn from Chapter Eight of the *1976 Medical Risks* Volume Five on other follow-up studies of moderate to severe hypertension. Kita has added the male and female EDR results of Sokolow and Perloff by initial severity class to a similar presentation of results of three other studies shown in Table 8-5, page 94 of the volume. The commentary on Table 8-5 in the *1976 Medical Risks*[5] provides a useful summary:

"Excess mortality of varying degrees was found in the grade one patients of all these series, often higher than in the Bolt, Bell and Harnes study of insurance applicants (§326). Although the methods of grading severity were different in each of these series, the cross-correlation of the indices used was such that identically numbered grades showed generally comparable levels of excess death rates. This is evident from the results by grade of severity in Table 8-5, which demonstrate a progressive increase in EDR with increasing severity in each series. There was no overlap in the range of EDRs from one grade to another: 14 to 49

Table 327L1-7

Severe hypertension in clinic outpatients, 1946-53, comparative mortality by age distribution and overall sex distribution (all severities combined)

Age/sex	*No. alive at start*	*No. 5-year survivors*	*No. deaths at 5 years*	*Survival rate*		*Mean ann. mort. rate per 1,000*			*Mortality ratio*
				5-year	*annual**	*observed*	*expected***	*excess*	
	ℓ	*s*	*d*	*P*	*p*	*q*	*q'*	*(q-q')*	*Percent*
<30 years	25	22	3	.880	.980	20	1.7	18	1,180
30-39	100	71	29	.710	.934	66	2.8	63	2,400
40-49	162	103	59	.636	.913	87	6.6	80	1,320
50-59	96	53	43	.552	.888	112	14.6	97	765
60-69	56	29	27	.518	.877	123	33.7	89	365
All ages									
Male	143	65	78	.455	.854	146	11.7	134	1,250
Female	296	213	83	.780	.936	64	8.2	56	780
Total	439	278	161	.633	.913	87	9.3	78	935

* Geometric mean annual $p=(P)^{1/5}$. Data by age group are from table 15 of reference 10
** Basics of expected mortality: 1949-51 US Life Tables for total males and total females (see table 327L1-3)

per 1,000 in males and 1.3 to 20 per 1,000 in females in grade one; 70 to 110 per 1,000 in grade two males, and 29 to 51 per 1,000 in females; 191 to 248 per 1,000 in males and 135 to 141 per 1,000 in females in grade three; and in grade four (malignant hypertension) 418 to 880 per 1,000 in males and 209 to 540 per 1,000 in females. Even higher excess death rates would have been found in the Mayo Clinic series (M) and the unoperated patients of Smithwick et al. (S) if more weight had been given to the mortality in the first two years. Mortality rates were so high in the patients with malignant hypertension that most of the deaths and exposures were concentrated in the first year of follow-up. The extremely wide range of excess mortality from grade one to grade four attests to the prognostic significance of the severity indices used in classifying the severity of hypertensive cardiovascular disease in these patients who did not have the benefit of modern antihypertensive chemo therapy."

As shown by Kita and by the tables in this article, excess mortality as classified by initial severity in the series of Sokolow and Perloff fits very well into the grade one to grade four results for the other three studies summarized in Table 8-5 of the *1976 Medical Risks* volume. Of course, what we have been describing in this article is outside the universe of medical risk used in underwriting applicants for individual life insurance. Such high risks are pertinent to structured settlements, which had not yet been invented as an insurance tool in FDR's era. Antihypertensive drugs have since greatly reduced the mortality in all grades of hypertension, when the patient can be persuaded to stick to a lifetime of medical supervision and treatment. This aspect is discussed in an editorial 12 accompanying Messerli's article.[1] The editorial is entitled, "Hypertensive crisis since FDR - a partial victory." It is far outside the scope of this article to touch on the revolution in management of hypertension since the antihypertensive drugs were first used in the early 1950s– the declining incidence of malignant hypertension, or accelerated hypertension or hypertensive crisis, excess mortality in treated patients of various grades of severity of their hypertension, improvements in treatment, and in the development of an active public health campaign for the detection and treatment of hypertension.

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