CONTINUED HYPERTENSION*

PROGNOSIS FOR SURGICALLY TREATED PATIENTS

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From October, 1938, to April, 1943, 263 unselected patients having so-called essential or malignant hypertension of the continuous variety were treated surgically. A thorough denervation of the splanchnic bed was performed in two stages spaced eight to ten days apart, utilizing the lumbo-dorsal (thoraco-lumbar) technique (Smithwick, 1940). The purpose of this communication is to discuss the present status of these patients, all of whom were operated upon at least five and at most nine and a half years ago. This report deals with 256 patients, or 97.3% of the total material; the other seven cases could not be traced. The investigation was prompted by the high mortality rate for patients in the later stages of hypertensive cardiovascular disease.

Method of Study

The cardiovascular status of these patients was evaluated before and after operation as carefully as possible, with particular reference to the cerebral, retinal, cardiac, and renal areas. The eyegrounds were examined and described by an ophthalmologist and classified into grades or groups conforming as closely as possible with those of Keith, Wagener, and Barker (1939). The heart was studied by means of the electrocardiogram and x-ray films, and evaluated clinically by a cardiologist. Information regarding the kidney was obtained by means of urinalysis, concentration tests, intravenous phenolsulphonphthalein excretion, with particular reference to the output in the first 15 minutes and the total output in two hours, and non-protein nitrogen determination. Intravenous pyelograms were obtained as a routine. Further information was obtained by gross inspection and, in some patients, by biopsies of the kidneys at the time of operation.

A special attempt has been made to acquire certain blood-pressure data on all patients in a standard fashion. These were obtained by performing a so-called postural and cold test, a modification of the Hines-Brown (Hines and Brown, 1933) cold test, after a period of two days of physical inactivity and bed rest. Patients whose diastolic blood pressure fell to below 90 mm. during this preliminary rest period were not included in this series, but were classified as having intermittent hypertension, which is regarded as an earlier stage of the disorder. The postural and cold test is performed in a quiet room after a rest period of 15 or 30 minutes on a comfortable bed. Readings of pulse and blood pressure are taken every minute for five minutes with the patient first lying, then sitting, then standing. When the average of the five readings in each position is calculated, the figure for the resting horizontal

position is almost invariably the lowest, and is used to divide patients into various groups according to the average resting diastolic level. This same figure is also used to divide patients into three types dependent upon the width of the pulse pressure in relation to the diastolic level. In Type I are placed those cases in which the pulse pressure is less than one-half of the diastolic pressure. Type II contains those cases in which the pulse pressure is equal to or is up to 19 mm. more than one-half the diastolic pressure. Type III includes those cases in which the pulse pressure is 20 mm. or more greater than one-half the diastolic pressure. After the postural test the patient assumes the horizontal position, and readings of pulse and blood pressure are continued at minute intervals for five minutes. One hand is then placed in ice-water for 60 seconds and readings of pulse and blood pressure are taken after 30 and 60 seconds of immersion. Readings are then resumed at intervals of a minute for five minutes. The patient then stands and the cold test is repeated exactly as in the horizontal position.

The purpose of these special tests is to obtain information concerning variations in blood pressure in response to the stimuli of posture and cold, and also to obtain information regarding variations in the width of the pulse pressure. Such variations may be very striking, and eventually may be used as a basis for further subdividing hypertensive patients into more similar categories. Finally a sedative test is performed. After a light supper the patient is given 3 gr. (0.2 g.) of sodium amytal by mouth at 7, 8, and 9 p.m. Hourly readings of pulse and blood pressure are recorded from 7 p.m. to 7 a.m. The lowest recorded level of systolic and diastolic pressure is taken as indicating the response.

Data Pertaining to Pre-operative Status and Corresponding Mortality

Male patients comprised 39.4% and female patients 60.6% of the series. The total mortality during the 5-9-years period of observation was 31.2%. The mortality among males was 34.3% and for females 29.1%. The difference in the mortality rates in the two sexes was slight (Table I). The mortality per operation was 2.2% and per case 4.3%. The causes of death are summarized in Table II.

TABLE I.—Mortality 5-9 Years After Operation

	No. of Cases	Living	Dead
Males	102 (39.4%)	67 (65.7%)	35 (34.3%)
Females	154 (60.6%)	109 (70.9%)	45 (29.1%)
Total	256 (100.0%)	176 (68.8%)	80 (31.2%)

*Read in opening a discussion in the Section of Surgery at the Annual Meeting of the British Medical Association, Cambridge, 1948.

TABLE II.—*Causes of Death*

	No. of Cases		No. of Cases
Cerebral	38 (47.5%)	Unrelated	8 (10.0%)
Cardiac	18 (22.5%)	Unknown	3 (3.8%)
Renal	13 (16.2%)	Total	80 (100.0%)

TABLE III.—*Age Distribution*

Age	No. of Cases	Mortality 5-9 Years after Operation
-10	1 (0.4%)	100.0%
10-19	4 (1.6%)	75.0%
20-29	27 (10.2%)	18.5%
30-39	90 (35.1%)	33.3%
40-49	112 (43.8%)	28.6%
50-59	21 (8.5%)	42.8%
60+	1 (0.4%)	0.0%
Total	256 (100.0%)	31.2%

The age distribution is indicated in Table III. It is apparent that the great majority of the patients were below 50 years of age. The mortality was highest in those below 20 and above 50. The bulk of the patients were between 20 and 49 years of age, and the average mortality for these age groups was essentially the same as for the series as a whole.

If patients were arranged according to pre-operative average resting diastolic levels it was apparent (Table IV)

TABLE IV.—*Distribution at Pre-operative Resting Diastolic Levels*

Diastolic Level	No. of Cases	Mortality 5-9 Years after Operation
90-99	21 (8.2%)	4.8%
100-109	33 (12.9%)	9.1%
110-119	51 (19.9%)	27.5%
120-129	61 (23.8%)	27.8%
130-139	39 (15.3%)	30.7%
140+	51 (19.9%)	64.8%
Total	256 (100.0%)	31.2%

that the mortality increased with the height of the blood pressure. For cases with levels below 110 mm. it was lowest; for cases with levels between 110 and 139 mm. it was much higher but relatively constant, and for those with levels of 140 mm. or more it was very high. At all levels the mortality rate was slightly greater for males than for females.

When the patients were arranged into groups according to the changes noted in the eyegrounds as suggested by Keith, Wagener, and Barker it was apparent in this series, as in theirs, that the prognosis became poorer as the grade of eyeground abnormality increased (Table V).

TABLE V.—*Pre-operative Eyeground Distribution*

Grade of Eyegrounds	No. of Cases	Mortality 5-9 Years after Operation
N	12 (4.7%)	16.7%
1	67 (26.1%)	13.8%
2	68 (26.6%)	26.3%
3	70 (27.3%)	45.7%
4	39 (15.3%)	48.8%
Total	256 (100.0%)	31.2%

TABLE VI.—*Pre-operative Cardiovascular Status**

	No. of Cases	Mortality 5-9 Years after Operation
Congestive failure and poor renal function	11 (4.3%)	100.0%
Congestive failure	23 (9.0%)	56.6%
Poor renal function	30 (11.7%)	53.3%
Cerebral accidents	39 (15.2%)	38.5%
Grade 3 eyegrounds	34 (13.3%)	29.4%
Grade 4 eyegrounds	15 (5.9%)	24.7%
Abnormal E.C.G., enlarged heart, or both	59 (23.0%)	13.5%
Grade 2 eyegrounds	19 (7.4%)	10.5%
Grade 1 eyegrounds	24 (9.4%)	4.2%
Symptoms only	2 (0.8%)	0.0%
Total	256 (100.0%)	31.2%

* In these ten subdivisions the status of the cardiovascular system as indicated by each heading was regarded as the most important abnormality of the cases in each category.

It was also informative to arrange cases according to other criteria of cardiovascular disease. The prognosis for surgically treated patients appeared to depend upon the original cardiovascular status (Table VI). Of those with poor renal function and congestive heart failure, for instance, no patient survived for five years after operation. The mortality in this group was 100%. At the other extreme were cases with minimal, grade 1 eyeground changes only. The mortality in this group was 4.2% during a similar period of observation. It was noteworthy, however, that in the whole series, all of whom had continuously elevated blood pressure, only two patients (0.8%) had no evidence of cardiovascular damage at the original examination.

Effect of Operation Upon the Cardiovascular System

The effect of operation upon the cardiovascular system may be judged by comparing the status of the eyegrounds, the electrocardiograms, and the renal function of living patients before and from five to nine years after operation. Of the 176 living patients 129 have been restudied five to nine years after operation, and such data as were available regarding the various vascular areas of these patients at the time of writing are summarized in Tables VII-IX. The

TABLE VII.—*Eyegrounds. Living Patients*

Pre-operative Status		Status 5-9 Years after Operation							
Original Grade	No. of Cases	Final Grade					Improved	No Change	Worse
		N	1	2	3	4			
N	6	0	4	2	0	0	0.0%	0.0%	100.0%
1	40	5	21	14	0	0	12.5%	52.5%	35.0%
2	32	3	24	20	4	0	9.4%	62.5%	28.1%
3	27	2	2	17	6	0	7.4%	22.2%	70.4%
4	15	2	7	5	1	0	13.3%	0.0%	86.7%
Total ..	120	14	37	58	11	0	40.7%	39.2%	20.1%

TABLE VIII.—*Electrocardiograms. Living Patients*

Pre-operative Status		Status 5-9 Years after Operation		
Status	No. of Cases	Improved	No Change	Worse
Normal	55	14.5%	80.0%	5.5%
Abnormal	70	64.3%	24.3%	11.4%
Total	125	42.3%	48.8%	8.9%

TABLE IX.—*Renal Function. Living Patients*

Pre-operative Status		Status 5-9 Years after Operation		
Status	No. of Cases	Improved	No Change	Worse
Normal	72	0.0%	93.2%	6.8%
Slightly impaired	26	77.0%	7.6%	15.4%
Moderately impaired	12	75.0%	8.3%	16.7%
Markedly impaired	4	100.0%	0.0%	0.0%
Total	114	28.9%	61.3%	9.8%

Renal function was judged by the intravenous phenolsulphonphthalein test. Normal: excretion of 25% or more of dye in 15 minutes and 60% or more in 2 hours. Slight impairment: excretion of 20 to 24% of dye in 15 minutes or 50 to 59% in 2 hours. Moderate impairment: excretion of 15 to 19% of dye in 15 minutes or 40 to 49% in 2 hours. Marked impairment: excretion of less than 15% in 15 minutes or less than 40% in 2 hours.

remaining 47 living patients have been checked during the 1-5-years period, but have not as yet been restudied during the 5-9-years interval.

With regard to the cerebral area, 39 patients had vascular accidents or encephalopathy before operation. Of these, 24 are living. Five have had subsequent cerebral accidents of a minor and non-fatal nature. Six of the 15 dead patients in this group of 39 had fatal cerebral accidents following operation. Of the living patients who did not have cerebral involvement before operation, three of 105 cases have had cerebral accidents during the 5-9-years period following operation. Of the 77 patients who have

TABLE X.—Cardiovascular Status. Living Patients

Pre-operative Status		Status 5-9 Years after Operation		
Vascular Area	No of Cases Examined	Improved	No Change	Worse
Retinal	120	40.7%	39.2%	20.1%
Cardiac (E.C.G.)	125	42.3%	48.8%	8.9%
Renal	114	28.9%	61.3%	9.8%
All (including cerebral)	100	51.0%	12.0%	37.0%

died since operation in which the cause is known with reasonable certainty, death was due to cerebral accidents in 38. If one takes all vascular areas into consideration it will be noted that although certain patients show improvement in one they may at the same time show progress of vascular damage in another area. In other cases there was progress in one or more vascular areas. In still others there was no progress in any area, while some cases showed improvement in one or more areas with no evidence of progress in any area. A composite picture of the patients considered as a whole is given in Table X, in which the changes in the retinal, cardiac, and renal areas already described are summarized, together with an evaluation of all areas in the first 100 cases to be checked in detail five to nine years after operation.

Effect of Lumbo-dorsal Splanchnicectomy Upon Blood Pressure

In previous reviews (Smithwick, 1944, 1947, 1948) it has been noted that the blood-pressure levels have been lowered markedly to slightly in the majority of unselected patients during a 1-5-years follow-up period. This was true in this series also, some degree of lowering of blood pressure being noted in 84 of 100 cases. When the blood-pressure levels of these same 100 cases were re-evaluated during the 5-9-years period we found that only 47 cases continued to have as great a lowering of blood pressure. This indicates clearly that there has been a gradual return of blood pressure towards or to the pre-operative levels in 44% of the cases in which the levels were lower during the earlier follow-up period. This trend is indicated by Table XI.

It is apparent that, when the cardiovascular status of the patient as a whole was considered in relation to the degree of lowering of blood pressure, progress of cardiovascular disease was least in those cases having the most marked lowering for the longest period of time and greatest in those having the least lowering (Table XII). This suggests that lowering of blood pressure is beneficial. It is also of interest that many of the cases showing no significant change in pressure at the end of the period of observation had cardiovascular systems which

TABLE XII.—Blood Pressure and Cardiovascular Status. Living Patients

Late Effect of Operation on Blood Pressure	No. of Cases	Cardiovascular Status 5-9 Years after Operation		
		Improved	No Change	Worse
Marked	21	81.1%	4.6%	14.3%
Moderate	13	76.9%	0.0%	23.1%
Slight	13	46.2%	23.1%	30.7%
No significant change	36	43.4%	17.8%	38.8%
Higher	17	11.7%	11.7%	76.6%
Total	100	51.0%	12.0%	37.0%

were actually in better condition than before operation, and in the majority of these cases there had been no evidence of progression of vascular disease.

FIG. 1.—Response to Valsalva test before and after lumbo-dorsal splanchnicectomy. Variations in blood pressure caused by reflex vasoconstriction are abolished when a large vascular area such as the splanchnic bed is denervated. These variations may be very marked, as in this case. This physiological effect of sympathectomy occurs regardless of whether the basal levels are altered or not and is well demonstrated by the Valsalva manoeuvre as in this figure. Intra-arterial blood-pressure levels are optically recorded with a Hamilton manometer before, during, and after a ten-second period of forced expiration. Before operation there was a sharp overshoot of blood pressure to very high levels within a few seconds after the expiratory period. After operation (shaded graph) the overshoot was abolished. It seems probable that the elimination of such reflex variations in blood pressure is partly responsible for the favourable changes in the cardiovascular system which may be noted after operation.

Slowing the rate of progress of cardiovascular disease after surgery may prove to be a very significant accomplishment. It should be remembered that most of these patients had lower average levels of blood pressure for one to five years. In addition, it may be assumed that virtually all of them had an abolition of the marked reflex vasoconstrictor response described by Wilkins *et al.* (1947, 1948), and that most of them continued to have these responses greatly reduced, if not abolished, for years after the operation. This change, which can be readily demonstrated by means of the Valsalva test (Fig. 1), constitutes a second physiological effect of lumbo-dorsal splanchnicectomy upon blood pressure and is not necessarily related to changes in basal levels. Examples of persistent and temporary reductions in basal blood-pressure levels are illustrated by Figs. 2 and 3.

TABLE XI.—Comparison of Early and Late Effect of Operation Upon Blood Pressure. Living Patients

Effect on Blood Pressure	No. of Cases in 1-5-Year Period	No. of Cases in 5-9-Year Period
Marked*	35	21
Moderate†	29	13
Slight‡	20	13
No significant change	11	36
Higher	5	17
Total	100	100

* Diastolic blood pressure lowered 20 mm. or more and to below 90.

† Diastolic blood pressure lowered 20 mm. or more and to below 110.

‡ Diastolic blood pressure lowered 10-19 mm. and to below 110.

FIG. 2.—This case, that of a 31-year-old physician, came to hospital with rather severe hypertension, Type I. This had been discovered within a year prior to admission. His symptoms were comparatively mild, and consisted of occasional headaches, ease of fatigue, and shortness of breath. There was no evidence of cerebral damage. The eyegrounds showed grade 1 changes. The electrocardiogram was abnormal, and is reproduced in Fig. 5. The heart was slightly enlarged. There was evidence of early congestive failure, as revealed by radiography of the chest and by the presence of alternation and gallop rhythm. This responded well to digitalis. The aorta was tortuous. The renal function was normal by ordinary tests. There was slight persistent albuminuria. The blood pressure fell to 135/98 on sedation. Five years after operation his general cardiovascular status was improved. His eyegrounds were unchanged. His heart was within normal limits as to size. There was no evidence of failure. He did not require digitalis. The electrocardiogram was normal (Fig. 5). The aorta was tortuous. The renal function was normal and there was no albuminuria. He was asymptomatic and had carried on a very active surgical practice since operation. In the upper portion of the figure the blood-pressure levels as revealed by the postural and cold test are compared before and one year after operation. In the lower portion of the figure the levels before and five years after operation are compared. The actual levels were as follows:

	Lying	Standing	Ceiling Cold		Cold Response	
			Lying	Standing	Lying	Standing
Pre-operative	160/122	179/147	204/160	218/170	30/20	28/20
Post-operative (1 year)	103/68	114/90	120/80	132/108	26/22	26/24
Post-operative (5 years)	110/78	122/98	136/110	164/122	26/22	30/12

This case was ideally suited for surgical treatment. The effect upon the blood-pressure level was marked (see Table XI) and persistent.

In general the most favourable cases are those in the younger age groups, with narrower pulse pressures (Types I and II), who have variable blood pressures, with resting diastolic levels below 140 mm. and preferably below 130 mm., with cardiovascular systems not too severely damaged, and with a satisfactory response to sedation.

FIG. 3.—This case, that of a 45-year-old male nurse, was admitted to hospital because of congestive heart failure. On examination he was found to have hypertension. The eyeground changes were very marked, with arterial constriction and sclerosis grade 2, haemorrhages and exudate, and papilloedema. It was therefore apparent that he had so-called malignant hypertension. There was no evidence of cerebral involvement. The heart was enlarged and the electrocardiogram was abnormal. The kidney function was normal by ordinary tests except for rather marked and persistent albuminuria. The blood pressure fell from a resting level of 202/121 to 142/86 on sedation. The resting level indicated that this patient had a wide pulse-pressure type of hypertension (Type III). These data indicated that the patient's outlook was serious. He responded well to bed rest and digitalization. Operation was performed and he recovered uneventfully. One year later he was much improved and was leading a normal existence without digitalis. His cardiovascular system was improved, as was his blood pressure. The effect of operation upon the blood-pressure level was graded as slight (see Table XI). Five years after operation his general condition was still improved and was the same as that noted at the end of the first year. The blood pressure had returned toward but had not quite reached the pre-operative levels. At this time his eyegrounds showed grade 2 changes, his heart was abnormal in size and shape but normal in function. The electrocardiogram was abnormal but improved by comparison with the pre-operative tracing. The renal function was normal by ordinary tests. There was no albuminuria. The blood-pressure levels are compared in the upper portion of the figure before and 13 months after operation. In the lower graph the levels before and five years later are contrasted. The blood-pressure levels during the postural and cold tests were as follows:

	Lying	Standing	Ceiling Cold		Cold Response	
			Lying	Standing	Lying	Standing
Pre-operative	202/121	226/146	246/155	250/166	26/28	20/20
Post-operative (1 year)	164/105	180/110	172/114	180/120	6/14	16/4
Post-operative (5 years)	201/127	185/130	214/140	200/150	24/22	10/18

This is an example of a worth-while but less satisfactory result when compared with the case illustrated by Fig. 2. The older age and presumably longer duration of the hypertension, and consequently more extensive vascular disease, are unfavourable signs. The wide

pulse pressure is also an unfavourable finding. The explanation for recurrence of hypertension following surgery is not clear. Regeneration may play a part but is not a satisfactory explanation, since the reflex response to the Valsalva manoeuvre and other stimuli may still be abolished years after operation. The status of the cardiovascular system at the time of operation appears to be equally if not more important in this connexion. Even though the blood-pressure levels may be lowered to a significant degree, if they are still considerably above the normal range vascular disease progresses, and in time the blood-pressure levels rise again. The more nearly the pressure approaches normal after operation the longer the respite from the disorder.

Life Expectancy of Hypertensive Patients: Comparison of non-surgically and surgically treated patients

Data reported on the life expectancy of hypertensive patients not treated surgically and observed for long periods of time are summarized in Table XIII. There is rather

TABLE XIII.—Mortality Among Hypertensive Patients Treated Medically or Untreated

Author	No. of Cases	Time Followed Up	Mortality
Janeway (1913)	458	1-10 years	5 years—50% 10 years—75% (53% of men; 33% of women)
Blackford, Bowers, and Baker (1930)	202	5-11 years	50% (70% of men; 39% of women)
Keith, Wagener, and Barker (1939)	219	5-9 years	91% (93% of men; 88% of women)
Rasmussen and Boe (1945)	100	6 years	52% (71% of men; 43% of women)
Bechgaard (1946)	1,038	4-11 years	28% (41% of men; 22% of women)

close agreement in the statistics of Janeway (1913), Blackford, Bowers, and Baker (1930), and Rasmussen and Boe (1945). About a half of their patients died during the course of some five years' observation. The mortality among men was considerably higher than among women. The findings of Keith, Wagener, and Barker (1939) and of Bechgaard (1946), however, differ widely from each other and from those of the previous authors. The Mayo group found that 91% of their patients died during a 5-9-years period of observation, the mortality for males being only slightly greater than that for females. Bechgaard reported an overall mortality of 28% during a 4-11-years period, that for men being about twice as great as for women.

It is apparent from these statistics that there is a wide variation in the mortality rates for hypertensive patients considered as groups. Further, it is obviously impossible to compare different groups of cases with each other, whether untreated or treated, unless they are divided into more comparable subgroups. In making these subgroups the numerous variables known to exist and to influence the outcome in this complex disorder should be held as constant as possible. In this way, and only in this way, can we arrive at a

reasonably accurate prognosis for a particular patient. Comparisons between such subgroups would then be of value and could be utilized to determine whether a particular therapeutic measure materially influenced the natural course of the disorder.

The first attempt to divide hypertensive patients into more comparable subgroups was made by Keith, Wagener, and Barker (1939). Their subdivision of a series of 219 patients into four groups was based upon the changes detected by a careful examination of the eyegrounds. Four grades were described, and the cases were grouped largely upon this basis. Survival curves were constructed for each group, and a material difference in prognosis for each of the groups was demonstrated. The survival curves for their four groups are reproduced in Fig. 4. We have arranged our cases into four similar groups. The survival curves for our series are also illustrated in Fig. 4. The two sets of curves are similar, and confirm their conclusion that the prognosis for hypertensive patients in the various groups differs materially. The survival rate in each of the four groups was higher in our surgically treated series. The differences observed have been subjected to statistical analysis, the results of which are summarized in Table XIV. The difference appears to be very significant for groups 2, 3, and 4, and increasingly so as the retinal changes become more severe. This suggests that the outlook for hypertensive patients has been improved by surgical therapy. It should be pointed out, however, that this subdivision into four groups, while no doubt a useful initial breakdown, permits of wide variations in the material contained within each group. When these four groups are further subdivided according to sex, age, severity of hypertension as judged particularly by the resting diastolic level, and the changes present in other vascular areas, it seems likely that the outlook for a particular patient can be assessed more accurately, and that the merits of a particular therapeutic

FIG. 4.—Survival curves following splanchnicectomy. 224 cases followed 5 to 9 years, arranged according to Keith-Wagener-Barker groups and compared with their 219 cases followed 5 to 9 years. As pointed out in the text, the division of hypertensive patients into more comparable subgroups is highly desirable. The division into four groups on the basis of eyeground changes is a step in the right direction, and is probably the most important initial breakdown which can be made. It still permits of wide variations in the material contained within each group. Consequently, further divisions are needed in which other important variables are held constant. This requires a larger number of cases, however, which we will have available as our follow-up studies progress. On the basis of the data at hand, it seems probable that the outlook for hypertensive patients treated surgically is improved in all stages of the disorder. The difference observed was found to be statistically very significant for groups 2, 3, and 4 (see Table XIV).

FIG. 5.—In this figure serial electrocardiographic tracings are recorded over a five-year period. This is the case illustrated by Fig. 2. The tracing immediately after operation was improved. That one year after operation was also improved, but not as much as that one week after splanchnicectomy. The tracing gradually improved and was regarded as within the normal range by the end of four years. It was still normal five years after operation.

measure may be evaluated with greater certainty. To do this will require large numbers of patients followed up for long periods of time.

TABLE XIV.—Significance of the Difference Observed Between the Survival Curves following Lumbo-dorsal Splanchnicectomy and those of Keith, Wagener, and Barker

Group	Time of Comparison*	χ^2	Probability of Difference Observed being Due to Chance Alone	Significance
1	62 months	0.694	45 in 100†	Not significant
2	86 "	10.5	1 in 1,000	Very "
3	77 "	18.6	1 in 100,000	" "
4	70 "	73.8	Less than 1 in 10 ⁶	" "

*When compared there were 58 of 67 survivals in the surgical and 7 of 10 in the non-surgical group 1 series. The corresponding numbers for the other groups were 50 of 68 and 9 of 26 in group 2, 39 of 70 and 4 of 37 in group 3, and 20 of 39 and 1 of 146 in group 4.

†It is ordinarily assumed that any probability of occurrence of less than 5 chances in 100 is not due to chance alone.

The only other comparison which can be made at the present time is between the electrocardiograms of surgically and non-surgically treated patients. The changes observed in 125 of our patients are compared with a series of 50 non-surgically treated patients reported by Canabal, Warneford-Thomson, and White (1945). All of the cases in each group were followed up for five years or more. The differences observed in the two groups have been analysed statistically and the data are summarized in Table XV. The differences appear to

TABLE XV.—A Comparison of the Electrocardiograms of Surgically Treated Patients with those of Non-Surgically or Untreated Hypertensive Patients

Series	No. of Cases	Status After 5 Years or More Observation		
		Improved	No Change	Worse
Surgical (Smithwick, 1948)	125	42.3%	48.8%	8.9%
Non-surgical (Canabal, Warneford-Thomson, and White, 1945)	50	10.0%	40.0%	50.0%

The observed difference between the two series is very significant. $\chi^2 = 40.8$. The probability that the observed difference is due to chance alone is less than 1 in 10⁶.

be very significant, and suggest that the course of hypertensive heart disease, as judged by the electrocardiograms, has been favourably modified by surgical therapy. Serial

electrocardiograms indicating a prolonged and favourable response to operation are illustrated by Fig. 5.

Summary

It should be recognized that the series of 256 cases of continued hypertension here studied is not representative of hypertensive patients as a whole, since it does not include those in the stage of intermittent hypertension. All had reached the stage of continued hypertension and 99% had some evidence of cardiovascular disease, which was regarded as serious in about 80% of the group. They, for the most part, are patients who had not responded to other therapeutic measures available at the time of operation. In some the disorder was discovered only shortly before operation and in a very advanced state. In a few the cardiovascular changes were minimal. The patients in this group are not so seriously ill as those of Keith, Wagener, and Barker, but are probably more advanced than the other series referred to. This group of cases is probably more comparable to that of Peet and Isberg (1946, 1948), who have made

the only other late follow-up studies of a sizable series of patients treated surgically.

Our patients have been divided into various groups according to sex, age, and resting diastolic levels. They have also been divided according to the state of the cardiovascular system before operation. The mortality is indicated in the tables, and varies greatly according to the many variable factors which are present in this disorder.

The effect of operation upon the cardiovascular system has been indicated by comparing the changes in various vascular areas before with those noted five to nine years after operation with particular reference to eyegrounds, electrocardiograms, renal function, and the vascular system as a whole. The effect of splanchnicectomy upon blood pressure is discussed briefly.

It is difficult to find comparable data in the literature concerning the prognosis for hypertensive patients treated medically or untreated. Survival curves following surgical treatment are compared with those of Keith, Wagener, and Barker. The survival rate was higher in all groups in the surgically treated series. The difference observed was found to be statistically very significant for groups 2, 3, and 4. The status of the electrocardiograms in a group of surgically treated patients is compared with that of a control series reported by Canabal, Warneford-Thomson, and White. The difference observed was also found to be very significant statistically. With regard to symptoms, over 90% of the patients who have so far been interviewed five to nine years after operation are improved in this respect.

Further comparison of surgically and non-surgically treated cases divided into similar subgroups in which the most important variables are held constant is desirable. Until this can be done the influence and relative merits of various therapeutic measures upon the course of hypertensive cardiovascular disease cannot be evaluated with certainty. Such comparisons as can be made at this time, while admittedly inadequate, suggest that surgical treatment has favourably altered the prognosis of many patients with continued hypertension and cardiovascular disease.

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THE SPHENOID SINUS*

BY

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In scanning the literature of sinusitis one has the impression that with the sphenoid, and even more with the posterior ethmoid, it is a case of "out of sight out of mind." The maxillary and the frontal cavities are so accessible for direct observation, transillumination, x rays, and treatment that they receive more than their share of attention. What we know of them is apt to be applied by inference to the others. To some extent this is practical, but the sphenoid has special attributes. Being of an anatomical and physiological nature they are of more than passing interest, since they constitute the basis of treatment.

I shall review briefly only those anatomical characteristics which among the sinuses are peculiar to the sphenoid. It develops that most of them are.

Situated in the depth of the nasal cavity out of the direct line of the air-stream, the sphenoid sinus is sheltered from cold and dust and dryness. In the normal nose only a small part of the face of the sphenoid is visible or even accessible. As to the cavity itself almost every part is in intimate contact with some structure capable of making serious trouble when disturbed.

Structure

On examining skulls one is often impressed with the thinness of the bony walls and the intimate relations which the pneumatized cavity assumes with neighbouring structures. It is almost as though some corroding or dissolving fluid had been at work in the bone, extending the cavity here and there, adapting it to the contours of the surrounding nerves and vessels, leaving only a mere shell of bone between. Sometimes even this disappears, and the normally adjoining structure finds itself, but for the lining mucosa, within the sphenoid cavity.

There are no fewer than 13 such structures: the dura mater, the pituitary body, the optic nerve and chiasm, the cavernous sinus, the internal carotid artery, the abducens nerve, the oculo-motor nerve, the trochlear nerve, the ophthalmic nerve, the maxillary nerve, the sphenopalatine ganglion, the sphenopalatine artery, and the pterygoid canal and its nerve.

Herniations of the mucosa through dehiscences in the bone have been known to occur. They may carry the cavity of the sphenoid sinus even beyond the normal limits of the sphenoid bone. Contrast this with the maxillary sinus, whose walls are relatively sturdy and accessible and whose environs are much less vulnerable.

There are histological and physiological differences as well. The inspired air passing the face of the sphenoid on its way to the pharynx misses the ostium, which lies lateral to the main current. The sphenoidal mucosa is quite thin, and being thoroughly protected from the evaporating effects

of air currents is very sparsely supplied with glands—a thing of primary importance to the surgeon.

The ostium, in any case, is likely to be a slit rather than a well-defined opening. When a high nasal obstruction occurs and there is swelling of the mucosa of the sphenothmoidal angle the ostium is closed. Ciliary streams within the sinus converging at the ostium are blocked and the mucus is retained. Since there are few glands and therefore scant mucus, the inundation is not comparable to that which occurs in the maxillary sinus.

Unless the invading organism is especially virulent the reaction is apt to be a low-grade affair, tending to chronicity if overlooked and producing a dense but relatively thin hyperplasia. Thick, redundant, polypoid hyperplasias do occur, but the type often encountered in the maxillary antrum is the exception. In evaluating roentgenographic shadows one should remember that it is possible even for this thin membrane to be so distended by a transient oedema as to obliterate the cavity completely.

Sinus Infections

The nature and proportion of severe sinus infections seem to depend somewhat upon climate, living conditions, and public health education. Not only do the majority of severe cases originate in communities where these are unfavourable, but on the whole their incidence has fallen off materially in one's own recollection as a result of early attention to minor infections and obstructions.

There is the occasional case of fulminating suppurative sphenoiditis, acute, invasive, destructive, threatening life. On this I shall not dwell, for there is little in its diagnosis or management that is debatable. Only the prognosis has been modified in recent years by the advent of the sulphonamides and the antibiotics. The management of anything less than such an emergency seems to me to call first for consideration of the ultimate recovery of physiological function. Under such conditions eradication of "pyogenic" membranes is apt to impede drainage permanently and should be the last instead of the first resort.

It is necessary to distinguish between an abscess and a pus-filled sinus, a distinction not usually made in years past. The abscess is a collection of infectious material lying in an adventitious cavity, requiring evacuation and obliteration to return the tissues to normal. The sinus, on the other hand, is an infected hollow anatomical structure having functioning parts temporarily deranged but capable of restoration. Obliteration of such a structure approximates normality no more than does the amputation of an arm or a leg, although it may become necessary in either case for special reasons.

In the older literature treatment does not take into account the physiological processes by means of which a sinus protects itself, and this is still true of many contemporary textbooks. Most of these are only rewritten from older textbooks, and though the author may have the courage to introduce new ideas he is somehow reluctant to discard old ones, however faulty. On the whole, treatment of sphenoiditis is suggested tentatively in the textbooks, with the reservation that, if this fails, measures more and more drastic must be applied. In the light of present knowledge it is clear that if the treatment suggested did not actually prevent recovery it could only retard it at best. At worst it produced a situation requiring the most drastic measures.

To clarify, Skillern (1923) relates that "a long cotton-carrier saturated with strong adrenaline-cocaine solution is introduced into the ostium and allowed to remain several minutes until the mucosa around the opening is shrunken, thereby enlarging the ostium." This is carried out daily with subsequent irrigation. It is known now that the

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