ESSENTIAL DIASTOLIC HYPERTENSION

An investigation into the relative merits of medical and surgical treatment, with a proposed new method of selection for sympathectomy

---

Marjory A. Keith, M.A., B.Ed., M.B. Ch.B., M.R.C.P. Ed.

Thesis presented for the Degree of Doctor of Medicine

March 1949

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

List of Tables and Figures

ESSENTIAL DIASTOLIC HYPERTENSION

An investigation into the relative merits of medical and surgical treatment.

INTRODUCTION.

It may seem to the reader who glances casually at the title of this thesis that no individual has any justification for adding to the already immense wealth of material on this subject unless he has discovered a new or startling fact, or has evolved a fresh or more accurate method of clinical research. Part of the work to be described in this paper will, it is hoped, be a demonstration of the result of new methods concerned in the first place with the comparison of the progress of two groups of hypertensive patients, differently treated, and secondly, with the selection of those cases most suitable for one or other type of treatment.

At the outset, let us make quite clear what is meant by the phrase "essential diastolic hypertension." Diastolic hypertension is a condition characterised by a diastolic blood pressure which is consistently above normal (i.e. 90 mm Hg or higher) under basal waking conditions which will be described in detail later. The diastolic pressure is an indication of the state of the arterioles in general at any given time, and the fundamental haemodynamic alteration in diastolic hypertension is an increased resistance to the outflow of blood in some greater or lesser portion of the arteriolar bed. As a result of this increased peripheral resistance the diastolic pressure, which represents the residual force in the circulation during/

during diastole, is elevated.

The systolic blood pressure is merely a measure of the myocardial response to this increased resistance against which it must work. At the onset of diastolic hypertension in any individual the diastolic pressure is slightly but definitely raised but the systolic pressure may be normal. As the condition persists the systolic pressure also will be elevated, the normal ratio of systolic to diastolic pressures in the average case of essential diastolic hypertension (when not in cardiac failure) being 1·7:1·0. In the later stages, however, when hypertensive heart failure has commenced, the systolic pressure falls with the failing myocardium while the diastolic pressure remains high, giving the effect of a "decapitated" hypertension. This is always an evil omen, as it indicates that the heart is now failing to cope successfully with the increased work still being given it to do.

It will now be clear that in arterial hypertension it is the diastolic pressure which is by far the more significant of the two; for this reason we have used only the diastolic pressures in progress tables, statistical working, etc., in the investigation to be described here.

Let us now take the matter further, and make clear what is meant by "essential" diastolic hypertension. For many years it has been realised that there are numerous conditions which produce an elevated diastolic pressure; excellent classifications of these conditions have been given by A.R.Gilchrist(25) and Page and Corcoran(39). Very briefly, such causes of raised diastolic pressure may be:

I EXTRA-RENAL/

I EXTRA-RENAL

- A. Neurological (space occupying intra-cranial lesions, mid-brain lesions, etc.)
- B. Endocrinal (suprarenal, pituitary, etc.)
- C. Peripheral (arteriolar spasm.)
  - 1) Toxic 2) ESSENTIAL or UNKNOWN

II RENAL ISCHAEMIA

- A. Occlusive vascular disease
  (renal arteriosclerosis, main renal artery stenosis, coarctation of the aorta, aberrant renal artery, etc.)
- B. Primary renal disease
  (chronic glomerulo-nephritis, chronic pyclonephritis, renal carcinoma, polycystic disease, nephroptosis.)
- C. Renal Reflux
  Hydronephrosis: congenital or acquired
  - 1. Bilateral: urethral obstruction
    - prostratic "
    - vesical neoplasm
    - pelvic " , etc.
  - 2. Unilateral: ureteric obstruction of various types.

In order to ensure that a case of diastolic hypertension is "essential" (or of unknown etiology) a careful history is obviously necessary to exclude the other possibilities listed above. The family history is especially valuable since in most cases of essential hypertension it is positive for that condition/

condition - "shocks", epistaxis, etc., being reported, whereas in hypertension of renal origin there is rarely a positive family history.

Essential diastolic hypertension accounts for 90-95% of all cases of hypertensive heart disease (65). Its incidence is widespread, its symptoms manifold, and it presents a mass of material for clinical research greater than that provided by almost any other condition.

The fundamental cause of this condition is, as we have seen, still unknown, but theories are by no means lacking. Increased peripheral resistance in man can result from heightened vaso-constrictor activity mediated neurogenically or humorally. Neurogenic over-activity of the vaso-constrictor fibres may be induced in various ways, for example, different pathways may be stimulated by a change in the environment (e.g. cold) and psychogenically as in emotional excitement; humoral vaso-constriction may be due to a single pressor substance, or a number of different substances, being circulated through the body to act locally on the arterioles, but the actual site of manufacture of these substances is still unknown although Goldblatt's (24) famous experiments on clamping the renal artery of a dog have seriously incriminated the kidney.

It may be that afferent impulses from an ischaemic kidney cause the output of some internal secretion which by central or peripheral action lead to generalised vaso-constriction; or it may be that the presence of an ischaemic kidney leads to the accumulation or new formation of some substance or to a disturbance of chemical equilibrium between substances normally/

normally present in the blood, resulting in a pressor action (25).

It has been found experimentally that "renal ischaemia" hypertension cannot be relieved by renal denervation, and can be produced in renally denervated animals (39); and also that hypertension due to renal ischaemia cannot be abolished by splanchnicectomy and coeliac ganglionectomy (60). Thus it appears that it is due to a humoral rather than a neurogenic mechanism and this is borne out by the fact that if a kidney is rendered ischaemic and the renal veins are obstructed, no hypertension results.

Further work by Tigerstedt and Bergman (60), Houssay, Fasciolo and Taquini (35), Page and Helmer (40), and Harrison, Grollman and Williams (31) has had as its consequence the finding of a pressor substance (called "angiotonin" and "hypertensin") produced by the kidney, and its neutralisation by other (anti-pressor) substances.

More recently the work of Trueta and his associates (61) suggests that under certain conditions the renal cortex is rendered ischaemic by a short-circuiting mechanism whereby the blood from the renal artery by-passes the cortex and travels direct to the medulla via the vasa recta. Experiments on rabbits have shown that this mechanism can be initiated by a neuro-vascular reflex and it is possible that further work on these lines may throw light on some of the problems of essential hypertension.

The most widely held theory at the present time is that in the hypertensive individual, the arterioles throughout the body have, through some direct toxic or nervous influence, or as

a/

a result of inherited vascular hyper-sensitivity, become irritable and pass into a state of vaso-constriction thus increasing the peripheral resistance.

To start with the increased resistance is slight and symptomless; later the course of events may vary: the arteriolar spasm may wax and wane and may finally disappear, giving rise to a spontaneous "cure." Or as more often occurs, it may become permanent, causing a variety of symptoms and shortening life to some extent. Finally, it may progress with extreme rapidity, causing arteriolar necrosis and the whole symptom-complex of "malignant hypertension."

The cause of essential diastolic hypertension being unknown, so also is the cure.

Medical treatment of such patients has included general measures such as a limitation of exertion, reduction in weight where necessary, the administration of sedatives and, for the headache which is the most common complaint, analgesics, venesection and the head-up bed.

Thiocyanate therapy has come into favour again in recent years, and in some series of cases the drug has proved of definite value in reducing blood pressure and relieving symptoms (20,41,15). But it is not suitable for use outside hospital since toxic reactions develop rapidly and the dose cannot be correctly gauged without regular estimations of blood thiocyanate (25,17,16,64,47).

In later years there have been introduced for the treatment of essential hypertension certain surgical procedures, which have developed to an extraordinary extent since surgery in this/

this condition was first contemplated by Danielopolu (27), Bruning (11) and Pende (45), and first carried out in the United States by Adson when in 1925 he performed a bilateral lumbar ganglionectomy in one patient with malignant hypertension.

Later the extent of the operation increased, and bilateral section of the lower thoracic and upper lumbar spinal nerve roots was introduced by Adson, Craig and Brown (1 and 2). This was considered rather too hazardous a procedure and subdiaphragmatic splanchnicectomy with resection of lumbar "ganglia" 1 and 2 was employed instead, first by Craig in 1932 and by Adson since 1935. Sympathectomy was not included in this operative technique as it was considered that the increased arteriolar resistance was localised to the splanchnic area and therefore adequately controlled by the resections just described.

This conception was later questioned, and surgery was extended to include a sympathetic denervation of the whole of the lower part of the body.

Peet first introduced the operation of bilateral supradiaphragmatic splanchnicectomy and lower dorsal ganglionectomy in 1933 and has used it since then in over 900 cases (42, 43). This manoeuvre was thought to be likely to improve the renal blood flow, but there has been no evidence in support of this theory.

More recently, Smithwick in 1940 introduced the technique of lumbo-dorsal splanchnicectomy (56, 66) and this has been the operation most frequently employed in recent years. It is a combination of the supra- and sub-diaphragmatic operations and is carried out bilaterally in two stages.

Briefly/

Briefly the technique is as follows: after resection of the 12th rib the thoracic ganglion chain up to T10 or T9 and the corresponding parts of the splanchnic nerves are removed. After division of the diaphragm the lower part of the splanchnic nerves is removed down to the coeliac ganglion. Resection of the lumbar sympathetic chain includes lumbar ganglia 1 and 2 and occasionally 3.

A more detailed description of the operation, anaesthesia, etc., is given by De Takats et al. (59).

Another and even more extensive type of sympathetic denervation is that carried out by Grimson (29, 28, 27) who performed subtotal to total paravertebral sympathectomy, splanchnicectomy and coeliac ganglionectomy. Besides the resections carried out according to Smithwick, the whole thoracic ganglion chain was removed, including the stellate ganglion.

Grimson points out that the advantage of this operation is that it results in a more permanent drop in blood pressure than do the less extensive procedures, since there is less chance of sympathetic nerve regeneration. After Grimson's operation the patients have bradycardia, and orthostatic hypotension is not associated with the tachycardia which invariably accompanies it after Smithwick's type of operation. But there are considerable disadvantages; for example, excessive sweating on those parts of the body not denervated, Horner's syndrome, and a higher mortality rate at operation.

These three last mentioned methods (those of Peet, Smithwick and Grimson) are those approved at present; of those three, Smithwick's technique is that most frequently employed, and/

and has been used in 75% of the cases to be described in the present investigation.

Those who uphold the surgical method of treatment do so not because it is an attack on a known fundamental cause of hypertension, thereby effecting a permanent cure, but because they feel that it offers the patient greater freedom from symptoms and possibly longer life than can be achieved by medical measures. Many writers, however, feel that the results of sympathectomy do not justify such a major procedure, time-consuming as it is for both surgeon and patient, and frequently productive of much discomfort in the immediate post-operative period.

We have felt for some time that the literature on this subject, especially that on the comparative results of medical and surgical treatment of essential hypertension, reveals a great need for careful investigation by the same worker (or group of workers) of a control group of medically-treated cases - a group which will be composed of individuals as well matched as possible with those composing the surgically-treated group.

Authors have frequently brought together two groups for comparison, one medically and the other surgically treated, but in most instances one group is the writer's own series whereas the other is made up of cases investigated and assessed by another individual with, necessarily, slightly different standards and technique in the grading of, for example, retinal, renal and cardiac efficiency, etc.

Wagener and Keith (63) and Keith, Wagener and Barker (38) report on series of medically treated cases of essential diastolic/

diastolic hypertension and their results have been used by surgical authors for comparison with their own cases.

Flaxman (19) describes a medical ~~surgical~~ series of his own compared with a Surgical ~~medical~~ series collected by Peet; Hammarström (30) compares his surgical cases with a series of non-operated patients described by Bechgaard (8), and so on.

In the work to be reported in this paper both medical and surgical groups have been examined and graded by the same individuals, thus ensuring a more constant standard, and, it is hoped, more accurate conclusions.

THE PROBLEM

The problem to be studied can be divided into four three parts:-

A. The follow-up of as many cases of essential diastolic hypertension as possible, of whom some had been medically and some surgically treated, and the assessment of the improvement or deterioration of each individual by comparing his state at the end of a definite period with that at the initial examination.

B. As this investigation was not planned in advance, alloting individuals alternately to each type of treatment with the definite aim of a statistical comparison of results, the onus was on the clinician to match the surgically-treated cases in retrospect with similar medically-treated patients so that they should be as comparable as possible in certain respects (retinal grade, cardiac efficiency, renal efficiency, age, etc.) and thus enable a "matched-group" statistical comparison to be made/

made at the end of the follow-up period.

C. The follow-up examinations and the group-matching being complete, a statistical evaluation of each type of treatment was to be carried out, with reference to the following points :-

1. Subjective symptoms, and fitness for work
2. Basic waking diastolic blood pressure
3. Retinal appearances
4. Cardiac efficiency
5. Renal efficiency
6. Mortality rate, and prognosis

D. A final part of the problem was to be an attempt to create an improved method of selection of patients who would be considered suitable for surgical treatment. Hitherto such selection has been too often made haphazardly and on the basis of clinical intuition rather than on a reasoned assessment of the individual's performance in certain clinical tests and his grading in certain perliminary clinical observations. No individual should be submitted to such a major surgical operation merely on the chance that he will benefit by it; on the other hand, neither should any patient be denied the undoubted benefits which sympathectomy can bestow, merely because of a low grading in one or two of the preliminary tests.

THE MATERIAL OF THE INVESTIGATION

The material employed in this investigation consisted of 151 cases of essential diastolic hypertension, of whom 96 were treated by medical measures, and 55 by surgery. A description of the medical measures used was given earlier in this paper and included all the simpler remedies, excluding thiocyanate or any other specific drug. Of the surgical cases 75% were treated by Smithwick's technique, the remainder (operated on several years earlier) had splanchnicectomy and lumbar sympathectomy including lumbar ganglia L1 and L2.

Of our 55 surgical cases, 6 had a unilateral operation. In 5 of these the result was so satisfying that a second operation was not considered necessary, but was held over as a further measure to be employed should symptoms recur; in the remaining case a chest infection necessitated prolonged convalescence and the second half of the operation has not yet been carried out as the patient's symptoms have diminished.

These 6 "unilateral" cases have therefore been included in the series as their results are fully comparable with those of the patients who had both sides denervated.

The "medical" group of 96 cases consisted of 31 males and 65 females; the "surgical" group of 55 cases comprised 23 males and 32 females.

The cases were also divided into two groups according to the severity of the hypertensive process, assessed by the retinal grading, which was done according to the method of Wagener and Keith (63). Retinal grades 1 to 3 inclusive were

classed/

classed as evidence of a "benign" hypertensive process, whereas retinal grade 4 was that associated with the rapidly progressive and severe type of "malignant" hypertension.

The medically-treated group of 96 cases consisted of 76 benign and 20 malignant cases; the 55 surgical cases included 45 benign and 10 malignant.

The "benign medical" group of 76 cases was composed of 17 males and 59 females; "benign surgical" cases comprised 18 males and 27 females.

The "malignant medical" group contained 14 males and 6 females; the "malignant surgical" consisted of 5 males and 5 females.

In tabular form the types of cases are more clearly seen in Table I.

With regard to the age distribution of these medical and surgical cases, this factor is dealt with in Table 2.

There follows now a detailed analysis of the distribution of our 151 cases in relation to the various observations and investigations carried out at the time when each case was first seen. The factors investigated, and in which each patient was graded, are as follows:

1. Duration of symptoms.
2. Severity of symptoms.
3. Basal waking diastolic blood pressure.
4. Retinal grade.
5. Cardiac efficiency.
6. Renal efficiency.

For many, but not all of the cases, additional factors

were/

TABLE 1.

A. Medical Cases

	Benign	Malignant	Total
Males	17	14	31
Females	59	6	65
Total	76	20	96

B. Surgical Cases

	Benign	Malignant	Total
Males	18	5	23
Females	27	5	32
Total	45	10	55

Table 1: To show the distribution of the cases between benign and malignant grades of hypertension.

TABLE 2.

A. **Females**

	Medical		Surgical	
	Benign	Malignant	Benign	Malignant
Range	20-71	31-57	19-54	36-45
Mean	48.5	55.4	33.8	43.0
Median	49.0	48.5	38.0	45.0

B. **Males**

	Medical		Surgical	
	Benign	Malignant	Benign	Malignant
Range	35-65	40-66	21-52	44-61
Mean	51.0	52.5	42.8	48.6
Median	49.0	51.5	45.0	46.0

Table 2: To show the range of age distribution, the median and mean ages for each group, male and female, benign and malignant.

were added - the electrocardiogram, a heart-size estimation, amytal sedation test, cold pressor test, and postural blood pressure test, but detailed statistical work was not carried out on these, as the numbers were rather small.

1. Duration of Symptoms

It is of interest to divide the cases into "benign" and "malignant", as the difference is striking. This is shown in Tables 3 and 4.

It is clear from the above Tables that the individuals classed as cases of malignant hypertension have significantly shorter histories than the "benign" cases. Those malignant patients who have longer histories were found on examination to have signs of long-standing benign hypertension with, superimposed, the more severe malignant phase. It must not be supposed, however, that all the malignant patients with short histories were of the type which is malignant from the onset, without any previous benign phase: in point of fact, of the medically treated cases, 20% were acutely malignant from the start, and 80% had this phase superimposed on long standing benign hypertension. In the surgically treated group only one case (10%) was malignant from the start.

2. Severity of Symptoms

At each patient's initial examination his symptoms were graded as follows:

A. None: symptom-free

B. Moderate: not rendering the individual unfit for work but still troublesome.

C./

TABLE 3

Benign Surgical

Duration of symptoms	Males	Females	Total	%
up to 1 year	4	10	14	36.8
over 1 and up to 2	0	5	5	13.2
" 2 " " " 4	4	6	10	26.4
" 4 " " " 6	2	1	3	7.9
" 6 " " " 8	0	1	1	2.6
" 8 " " " 10	2	1	3	7.9
over 10 years	1	1	2	5.2
Totals:	13	25	38	100%

Benign Medical

Duration of symptoms	Males	Females	Total	%
up to 1 year	5	17	22	44%
over 1 and up to 2	3	4	7	14%
" 2 " " " 4	1	5	6	12%
" 4 " " " 6	0	6	6	12%
" 6 " " " 8	1	2	3	6%
" 8 " " " 10	2	3	5	10%
over 10 years	0	1	1	2%
Totals:	12	38	50	100%

Table 3: To show the duration of symptoms in those benign cases for whom this is known.

TABLE 4

Malignant Surgical

Duration of Symptoms	Males	Females	Total	%
up to 1 year	4	3	7	70%
over 1 and up to 2	1	0	1	10%
" 2 " " " 4	0	0	0	
" 4 " " " 6	0	0	0	
" 6 " " " 8	0	1	1	10%
" 8 " " " 10	0	0	0	
over 10 years	0	1	1	10%
Totals:	5	5	10	100%

Malignant Medical

Duration of Symptoms	Males	Females	Total	%
up to 1 year	12	4	16	80%
over 1 and up to 2	1	1	2	10%
" 2 " " " 4	1	0	1	5%
" 4 " " " 6	0	0	0	
" 6 " " " 8	0	1	1	5%
" 8 " " " 10	0	0	0	
over 10 years	0	0	0	
Totals:	14	6	20	100%

Table 4: To show the duration of symptoms in malignant cases.

C. Very severe - patient unfit for work

In tabulating the initial symptom grades of surgical and medical patients, we have grouped them according to their retinal grade, i.e. presumably according to the severity of the hypertensive process. The retinal grades, according to Wagener and Keith, range from 0 (normal) to IV(malignant hypertension), and a detailed description of them will be given in the appropriate section. At present the numbers 0, I,II,III andIV will suffice to indicate the degree of intensity of the hypertensive process, and the correlation of the severity of symptoms with this measurement is seen in Table 5.

Graphically, the distribution of grades of severity of symptoms for all surgical and all medical cases is shown in Fig. I; from this it is clear that amongst the surgically treated cases there is a much higher percentage of individuals with severe and incapacitating symptoms than is found in the medically-treated series. It will be seen later in the report whether this state of affairs had any adverse effect on their subsequent progress.

3. Retinal Grading.

As we have previously stated, the classification of Wagener and Keith (63) was employed in this investigation, the standards for each grade being as follows:

Grade 0: Normal

" I: Slight irregularity of the arterioles with patchy narrowing of the lumen and no other abnormality.

" II: Grade I findings, with, in addition, arterio-venous "nipping" where those vessels cross one another

Grade III/

TABLE 5

Surgical Cases

Retinal Grade	Males A	Males B	Males C	Females A	Females B	Females C	Total
0	-	-	3	-	1	6	10
1	-	1	4	-	-	13	18
2	-	-	8	-	-	6	14
3	-	-	2	-	-	1	3
4	-	-	5	-	-	5	10
Totals:	-	1	22	-	1	31	55

Medical Cases

Retinal Grade	Males A	Males B	Males C	Females A	Females B	Females C	Total
0	-	3	-	-	14	7	24
1	-	1	2	-	2	11	16
3	-	1	7	-	4	14	26
4	-	1	13	-	-	6	20
Totals:	-	7	24	-	20	45	96

Table 5: To show the distribution of grades of severity of symptoms (A, B, C) correlated with the retinal grade.

FIG. I

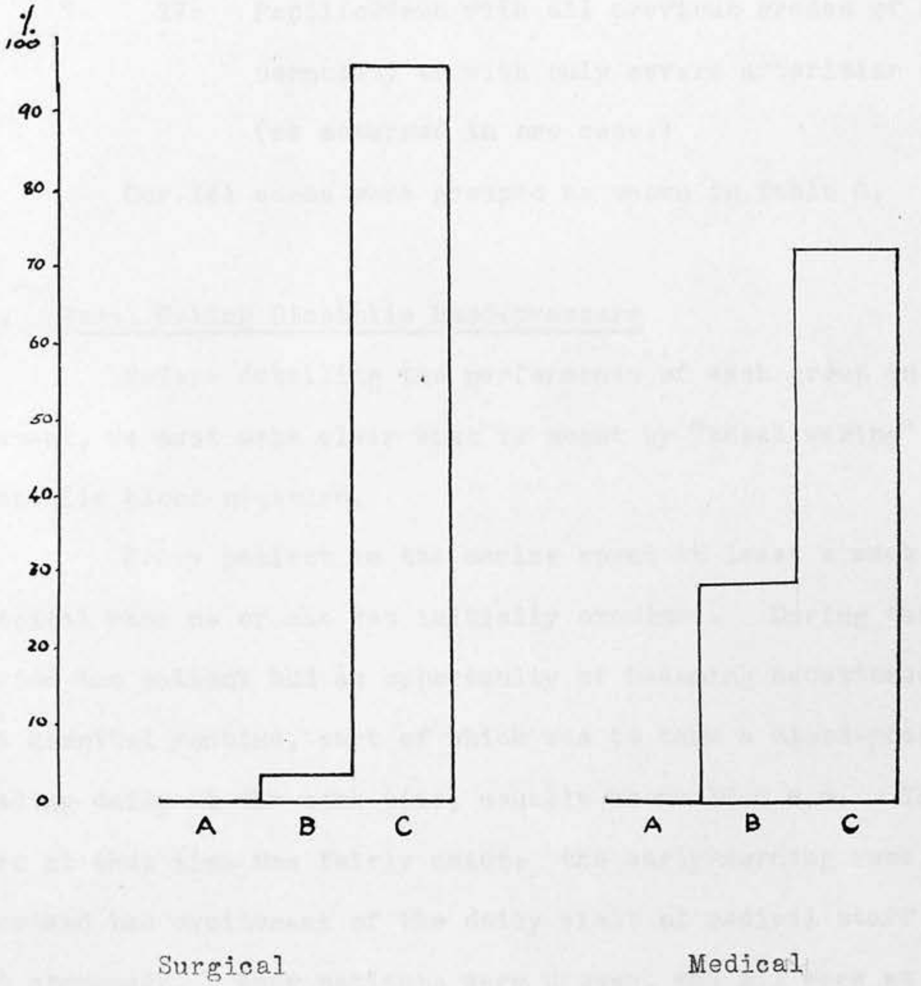


Fig. I: To show the percentage distribution among the three symptom-grades of the 55 surgical and 96 medical cases at the initial examination.

Grade III: Grade I and Grade II findings, with haemorrhages and exudates: i.e. hypertensive retinitis

" IV: Papilloedema with all previous grades of abnormality, or with only severe arteriolar spasm (as occurred in one case.)

Our 151 cases were grouped as shown in Table 6.

4. Basal Waking Diastolic Blood-pressure

Before detailing the performance of each group in this respect, we must make clear what is meant by "basal waking" diastolic blood-pressure.

Every patient in the series spent at least a week in hospital when he or she was initially examined. During that period the patient had an opportunity of becoming accustomed to the hospital routine, part of which was to take a blood-pressure reading daily at the same time, usually about 10.0 a.m. The ward at that time was fairly quiet: the early-morning rush was over and the excitement of the daily visit of medical staff had not commenced. Many patients were drowsy, and all were as peaceful as at any time during their waking hours. The lowest of the daily blood-pressure readings taken at this time was recorded as the basal waking pressure.

For ease in tabulating the results the basal waking diastolic pressures are placed in five groups as shown in Table 7.

The distribution of diastolic pressures for surgical and medical cases is set out in Table 8, showing the relation of diastolic pressure to retinal grade.

From this table it appears that there is a slight but

positive/

TABLE 6

Retinal	Surgical			Medical		
Grade	Male	Female	Total	Male	Female	Total
0	3	7	10	3	21	24
1	5	13	18	3	13	16
2	8	6	14	8	18	26
3	2	1	3	3	7	10
4	5	5	10	14	6	20
Totals:	23	32	55	31	65	96

Table 6: To show the distribution of all cases over the retinal grades 0-4

TABLE 7

Group	Diastolic Pressure
1	below 90 mm Hg.
2	90-99 mm Hg.
3	100-109 mm Hg.
4	110-119 mm Hg.
5	120 mm Hg. and over

Table 7:

TABLE 8

Surgical Cases

	Males					Females					Total
Retinal	D.B.P. group					D.B.P. group					
Grade	I	II	III	IV	V	I	II	III	IV	V	
0	-	1	1	-	1	1	-	2	-	4	10
1	-	1	1	2	1	1	1	3	-	8	18
2	-	-	2	-	6	-	1	-	2	3	14
3	-	-	-	2	-	-	-	1	-	-	3
4	-	-	-	-	5	-	-	-	-	5	10
Totals:	-	2	4	4	13	2	2	6	2	20	55

Medical Cases

	Males					Females					Total
Retinal	D.B.P. group					D.B.P. group					
Grade	I	II	III	IV	V	I	II	III	IV	V	
0	-	2	1	-	-	3	5	4	6	3	24
1	-	1	1	1	-	-	2	4	4	3	16
2	-	-	2	4	2	-	1	6	3	8	26
3	-	-	-	-	3	-	-	1	1	5	10
4	-	-	-	-	14	-	-	-	-	6	20
Totals:	-	3	4	5	19	3	8	15	14	25	96

Table 8: To show the distribution of the grades of waking diastolic pressure and the correlation of this finding with retinal grade (D.B.P. grades I to V as described in text)

positive correlation between retinal grade and diastolic pressure grouping, a state of affairs which is to be expected.

If we take all the surgical cases together and make a distribution graph of the percentage of cases in each blood pressure group, and repeat this procedure for the whole medical group, we get a result which is reproduced in Fig. II.

Of the 55 surgical cases, 60.1% have basal diastolic pressures above 120 mm Hg.; of 96 medically treated cases, only 46.6% had diastolic pressures in this group at their initial investigation. In this respect again the surgical cases seem to have started off with a poorer outlook than the medical cases.

5. Cardiac Efficiency

With respect to this criterion, the categories in which our patients were placed at their initial examination are four in number:

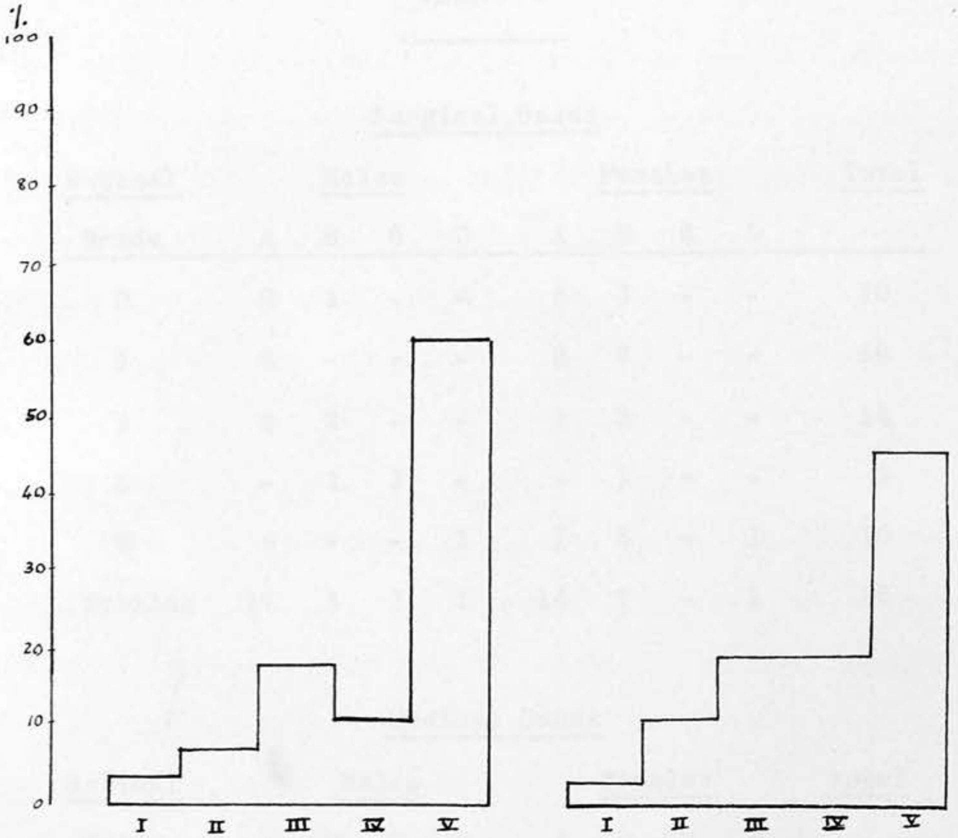
Grade	Cardiac Efficiency
A	Normal: no cardiac symptoms whatever
B	Slight to moderate dyspnoea on exertion.
C	Considerable to severe dyspnoea on exertion, with or without oedema; early cardiac failure.
D	Dyspnoea at rest - marked cardiac failure

Table 9 shows the distribution of the cases amongst these four grades, correlated with the retinal grade of each patient.

There is little if any correlation between the retinal grouping and the grade of cardiac efficiency.at the first exami-

nation/

FIG. II



Surgical Medical

Fig. II: To show the percentage **distribution among** the five grades of basic diastolic pressure levels of the 55 **surgical** and 96 medical cases at the initial examination

TABLE 9

Surgical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	2	1	-	-	4	3	-	-	10
1	5	-	-	-	6	7	-	-	18
2	6	2	-	-	3	3	-	-	14
3	-	1	1	-	-	1	-	-	3
4	4	-	-	1	1	3	-	1	10
Totals:	17	4	1	1	14	7	-	1	55

Medical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	2	1	-	-	14	6	1	-	24
1	1	2	-	-	6	3	4	-	16
2	2	-	4	2	5	8	5	-	26
3	1	1	1	-	3	4	-	-	10
4	5	2	2	5	-	2	3	1	20
Totals:	11	6	7	7	28	23	13	1	96

Table 9: To show the distribution of cardiac effieiency grades (A, B, C, D) correlated with retinal grade.

nation. The percentage distribution of each group treated as a whole with respect to cardiac efficiency grading is shown graphically in Fig. III from which it appears that there is a higher percentage of cases with moderate and marked cardiac failure in the medical series than in the surgical:-29.1% as against 5.3%; and 56.1% of the surgical are symptom-free in this respect as compared with 40.7% of the medical series. On the basis of this test, therefore, the surgical cases on the whole have a better outlook.

6. Renal Efficiency

Renal efficiency was assessed by the use of the Urea Concentration Range test (13) in practically every case, and in the odd one or two not so tested, the Van Slyke Urea Clearance test (46) was employed.

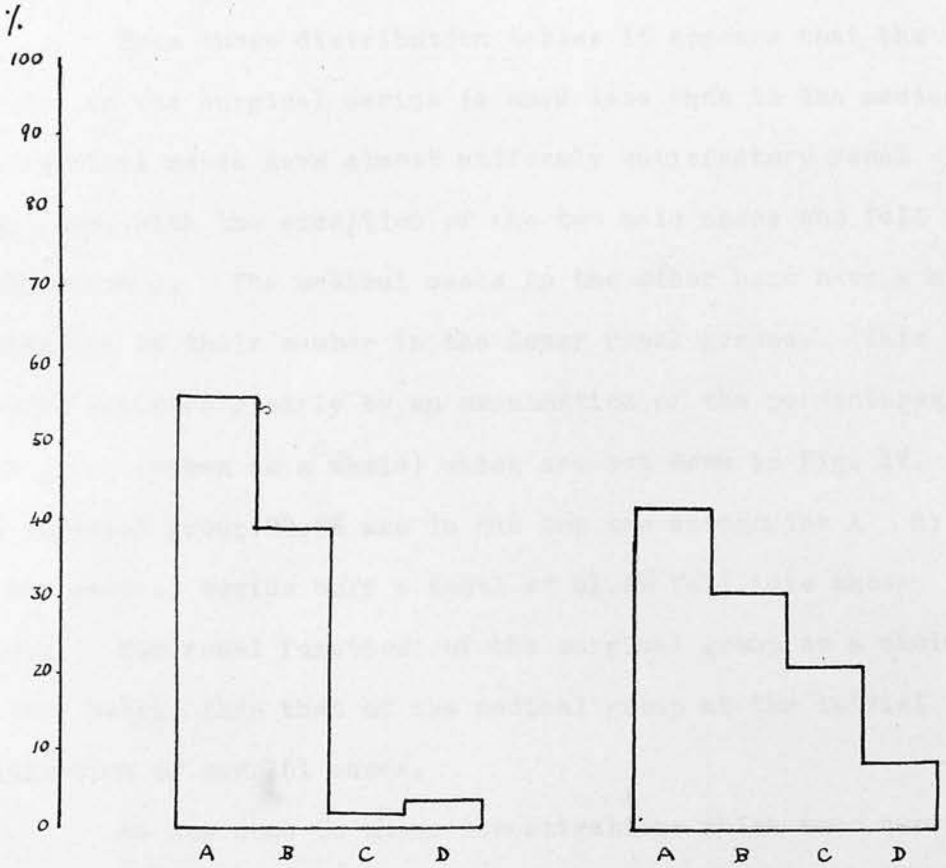
The results were graded as follows:

Grade		Performance in Urea Range Test
A	(very good)	Range of urea excretion of 3.0 gm% or more.
B	(good)	Range of urea excretion of 2.0 gm.% to 2.9 gm.%
C	(moderate)	Range of urea excretion of from 1.0-1.9 gm.%
B	(poor)	No range; a fixed low level of urea excretion of 0.9 gm.% or less

The Van Slyke test results are similarly graded to match the above types of response so that we have an estimate of renal function for every patient.

The/

FIG. III



Surgical Medical

Fig. III: To show the percentage distribution among the four grades of cardiac efficiency of the 55 surgical and 96 medical cases at their initial examination.

The distribution of results, correlated with retinal grading, is set out in Table 10.

From these distribution tables it appears that the scatter in the surgical series is much less than in the medical. The surgical cases have almost uniformly satisfactory renal functions, with the exception of the two male cases who fell into renal gráde C. The medical cases on the other hand have a higher proportion of their number in the lower renal grades. This is brought out more clearly by an examination of the percentages of each group (taken as a whole) which are set down in Fig. IV. Of the surgical group 96.5% are in the top two categories A, B; of the medical series only a total of 61.5% fall into those groups. The renal functions of the surgical group as a whole is thus better than that of the medical group at the initial examination of our 151 cases.

We now come to those investigations which were carried out on only a proportion of the patients in the series. The tests now to be described are not to be taken into account in the statistical comparison of the results of the two methods of treatment, nevertheless it is of interest to note the performance of such patients as were investigated in relation to the following factors:

7. Electrocardiogram.

The total number of patients who had an electrocardiogram carried out as part of their initial examination was 135, 46 surgical and 89 medical. A much smaller humber, however, had this repeated after treatment, hence the omission of this series of observations from the statistical analysis.

Taking/

TABLE 10

Surgical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	1	2	-	-	6	1	-	-	10
1	3	2	-	-	6	7	-	-	18
2	5	3	-	-	5	1	-	-	14
3	-	1	1	-	-	1	-	-	3
4	-	4	1	-	-	5	-	-	10
Totals:	9	12	2	-	17	15	-	-	55

Medical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	3	-	-	-	6	10	3	2	24
1	-	1	2	-	3	7	2	1	16
2	1	4	3	-	8	8	2	-	18
3	-	1	2	-	-	5	1	1	10
4	-	1	1	12	-	-	-	6	20
Totals:	4	7	8	12	17	31	7	10	96

Table 10: To show the distribution of renal efficiency grades (A, B, C, D) correlated with retinal grade.

FIG. IV

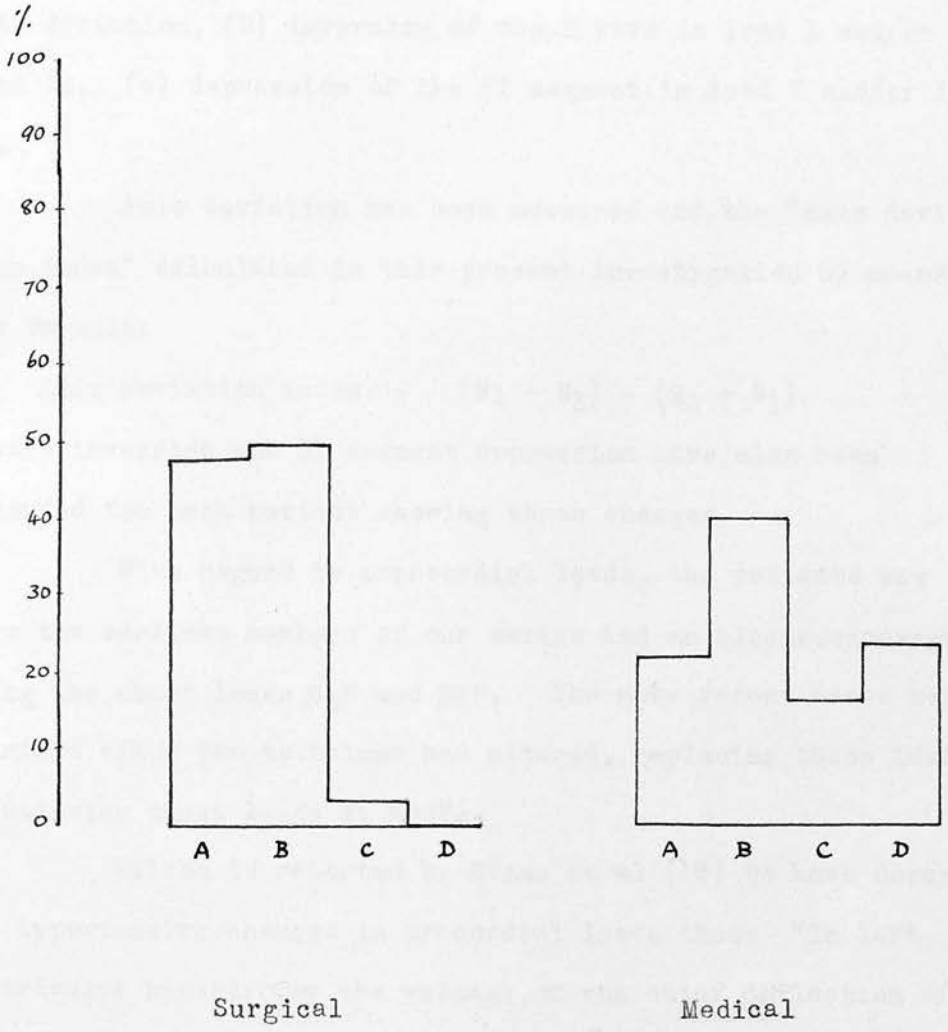


Fig. IV: To show the percentage distribution among the four grades of renal efficiency of the 55 surgical and 96 medical cases at the initial examination.

Taking first the standard limb leads of the electrocardiogram, the typical changes seen in hypertension are (a) left axis deviation, (b) inversion of the T wave in lead I and/or lead II, (c) depression of the ST segment in lead I and/or lead II.

Axis deviation has been measured and the "axis deviation index" calculated in this present investigation by means of the formula:

Axis deviation index :- $(R_1 + S_3) - (R_3 + S_1)$

T wave inversion and ST segment depression have also been measured for each patient showing these changes.

With regard to praecordial leads, the patients who were the earliest members of our series had an electrocardiogram using the chest leads C_2F and IV_4F. The more recent cases were examined after the technique had altered, replacing these leads by unipolar chest leads V_1 to V_6.

Wilson is reported by Evans et al. (18) to have described the hypertensive changes in precordial leads thus: "In left ventricular hypertrophy the voltage of the chief deflection of QRS is on the average much greater than normal, and the QRS interval is increased to 0.10 or 0.11 seconds. In leads from the right side of the praecordium the R deflections are, on the average, much smaller than normal, and may be absent. The transitional zone is usually displaced to the left. In leads from the left side of the praecordium, R, and often Q as well, are abnormally large; the peak of R occurs abnormally late in the QRS interval, and T is inverted."

The/

The electrocardiograms of our series of cases (all of which were taken with the patient recumbent) have been put in four categories in order of degree or abnormality:

Grade	Character of Electrocardiogram
A	Normal
B	Left axis deviation <u>or</u> T inversion
C	<u>Both</u> the changes in grade B
D	Fully developed patterns of left ventricular hypertrophy in chest leads from spots over the left ventricle, i.e. large R with or without a small Q, ST depression and inversion of T. (illustrative E.C.G. facing p.57).

The results of this grading can be seen in Table 11.

Percentages are graphed in Fig. V. There is no significant difference between the distributions of the two groups at this initial examination, except that the surgical cases tend to "peak" in grade B, whereas the medical electrocardiograms are scattered more evenly over the four grades.

8. Heart Size.

This observation was made clinically and radiologically in the case of every patient but two at the initial investigation.

Clinically the heart-size was frequently difficult and often almost impossible to estimate with any degree of accuracy owing to obesity, a thick chest wall, or other interference.

Radiologically however a more accurate estimate could be made, and the method followed was that described by Ungerleider and/

TABLE 11

Surgical Cases

Retinal Grade	Males A	Males B	Males C	Males D	Females A	Females B	Females C	Females D	Total
0	-	-	1	-	3	4	-	-	8
1	1	1	1	-	1	7	4	-	15
2	2	2	4	-	-	4	-	-	12
3	-	2	-	-	-	1	-	-	3
4	-	-	1	2	-	2	2	1	8
Totals:	3	5	7	2	4	18	6	1	46

Medical Cases

Retinal Grade	Males A	Males B	Males C	Males D	Females A	Females B	Females C	Females D	Total
0	2	1	-	-	8	7	4	1	23
1	3	-	-	-	3	9	-	-	15
2	-	2	2	4	2	6	6	3	25
3	-	2	-	1	-	2	2	3	10
4	-	-	4	7	-	-	5	-	16
Totals:	5	5	6	12	13	24	17	7	89

Table 11: To show the distribution of electrocardiogram grading (A, B, C, D) correlated with retinal grade.

FIG. V

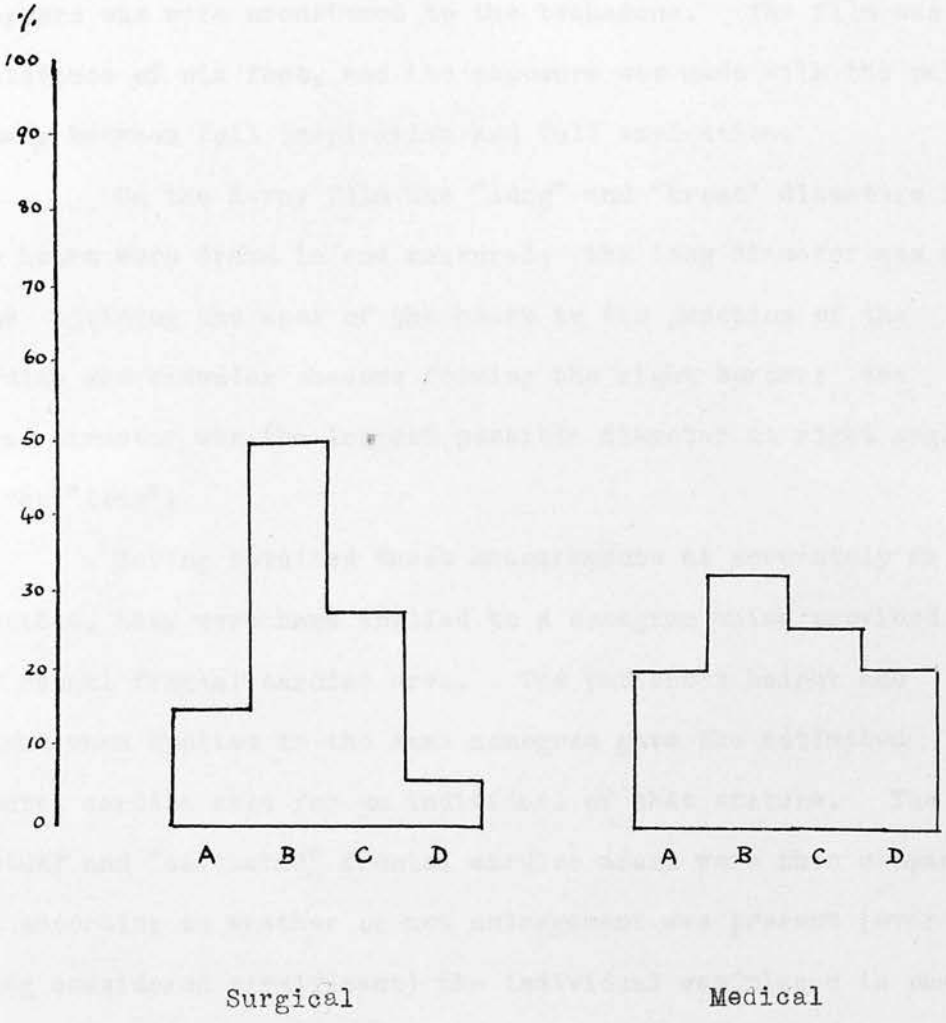


Fig. V: To show the percentage distribution among the four electrocardiogram grades of 46 surgical and 89 medical patients at the initial examination.

and Gubner (62) in 1942.

The patients were X-rayed by the same pair of radiographers who were accustomed to the technique. The film was at a distance of six feet, and the exposure was made with the patient midway between full inspiration and full expiration.

On the X-ray film the "long" and "broad" diameters of the heart were drawn in and measured; the long diameter was the line joining the apex of the heart to the junction of the cardiac and vascular shadows forming the right border; the broad diameter was the longest possible diameter at right angles to the "long".

Having obtained these measurements as accurately as possible, they were then applied to a nomogram which provided the actual frontal cardiac area. The patient's height and weight when applied to the same nomogram gave the estimated frontal cardiac area for an individual of that stature. The "actual" and "estimated" frontal cardiac areas were then compared and according to whether or not enlargement was present (over 10% being considered significant) the individual was placed in one of the following grades:

Grade	Heart-size
A	Normal - 10% enlarged
B	11%-30% enlarged
C	31%-50% enlarged
D	Over 50% enlarged

Table 12 shows the result of this grading, and Fig VI shows the percentages of surgical and medical cases in each heart-size grade

As/

TABLE 12

Surgical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	2	1	-	-	1	6	-	-	10
1	1	2	-	-	4	8	1	-	16
2	2	4	2	-	1	4	1	-	14
3	-	1	1	-	-	1	-	-	3
4	1	1	2	1	-	3	2	-	10
Totals:	6	9	5	1	6	22	4	-	53

Medical Cases

Retinal	Males				Females				Total
Grade	A	B	C	D	A	B	C	D	
0	2	1	-	-	11	9	1	-	24
1	1	2	-	-	4	7	1	1	16
2	1	4	2	1	5	10	3	-	26
3	-	1	2	-	1	5	1	-	10
4	1	3	8	2	-	2	1	3	20
Totals:	5	11	12	3	21	33	7	4	96

Table 12: To show the distribution of grades of heart-size (A, B, C, D) correlated with retinal grade.

FIG. VI

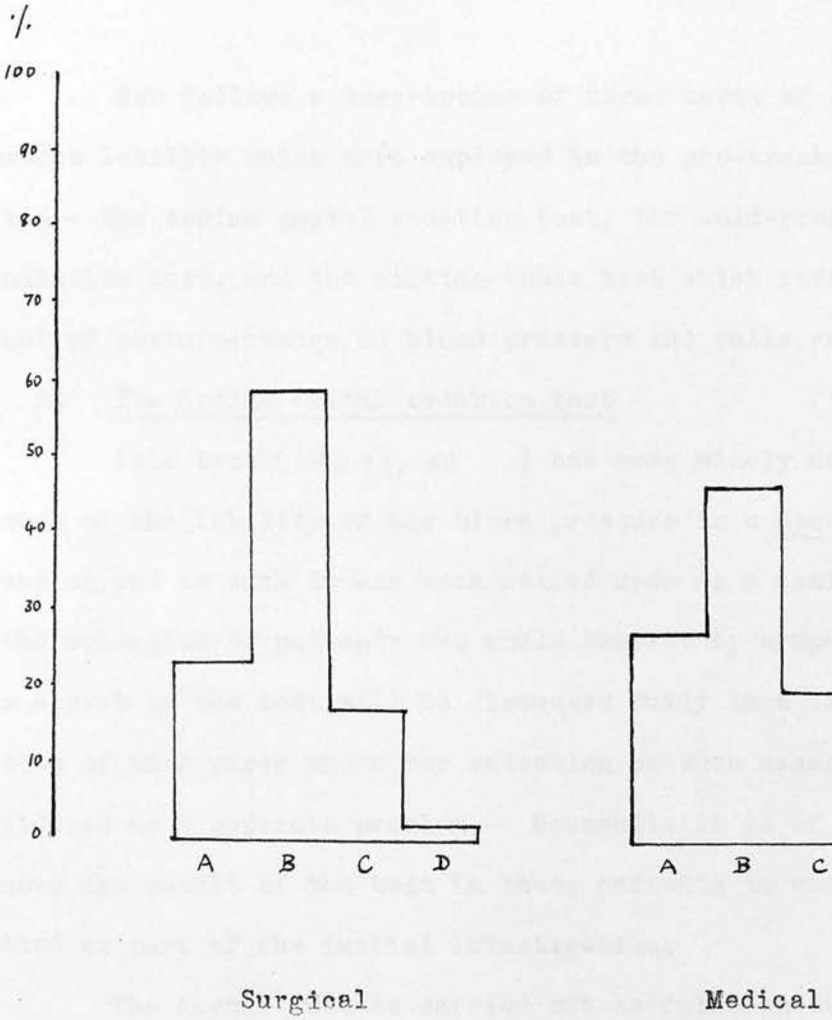


Fig. VI: To show the percentage distribution among the four heart-size grades of 53 surgical and 96 medical cases at the initial examination.

As was found in the electrocardiograms result, there is no real difference here between the two groups.

Now follows a description of three tests of blood pressure lability which were employed in the pre-treatment period - the sodium amytal sedation test, the cold-pressor stimulation test, and the tilting-table test which revealed the effect of posture-change on blood pressure and pulse rate.

A. The Sodium amytal sedation test

This test (4, 12, 49) has been widely used as a measure of the lability of the blood pressure in a downward direction, and as such it has been relied upon as a useful test in the selection of patients who would benefit by sympathectomy. This aspect of the test will be discussed fully in a later section of this paper where the selection of such cases will be considered as a separate problem. Meanwhile it is of interest to note the result of the test in those patients to whom it was applied as part of the initial investigation.

The Amytal test is carried out as follows: the patient, comfortably warm in bed, is placed if possible alone in a quiet room and blood pressure readings are taken every 5 or 10 minutes for 30 or 45 minutes, the sphygmomanometer cuff remaining on the arm between readings.

When a satisfactory base-line of blood pressure readings has been obtained, the patient is given a 3-grain capsule of Sodium Amytal and left undisturbed for half an hour, when another reading is taken. At the end of an hour, the blood pressure/

pressure is again taken, and a second 3-grain capsule given, followed by half-hourly readings as before. At the end of the second hour, if the patient is awake, a third dose of 3 grains of sodium amytal is given, and the blood pressure registered half-hourly thereafter until the patient wakes up.

Briefly, the lowest diastolic figures achieved by each individual have been (as were the basic waking diastolic figures) grouped into five grades: Grade I below 90 mm Hg., Grade II 90-99 mm Hg; Grade III 100-109 mm Hg; Grade IV 110-119 mm Hg; and Grade V 120 mm Hg. and over.

The distribution of the surgical and medical groups is seen in Table 13, and the percentage in each diastolic grade in each of the two groups taken as a whole is seen in Fig. VII. There is very little difference between the two results, the medical group having a slightly larger proportion in the lowest diastolic group.

B. The Cold Pressor Test

This test, which is designed to measure the lability of the blood pressure in an upward direction (Hines and Brown(32, 33,34)) is performed thus: the patient lies comfortably on a couch in a room at a moderate temperature. A series of blood-pressure readings is taken, one every 2 or 3 minutes, to obtain a base line. Then at a signal the patient places his free hand in a basin of ice-water, immerses it to the wrist and keeps it there for 1 minute, during which time 2 blood pressure readings are taken. The patient then removes his hand from the ice-water and blood pressure readings are taken every minute until they /

TABLE 13

Surgical Cases

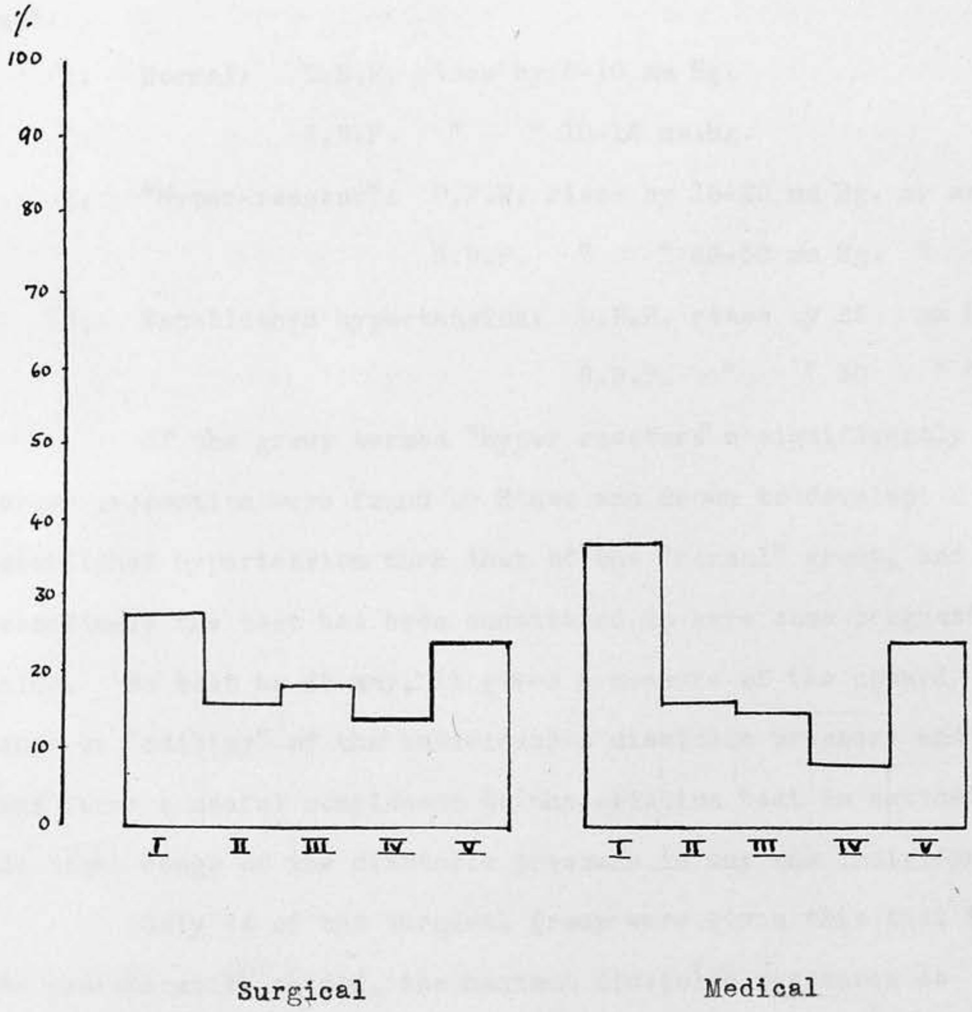
Retinal	Males					Females					Total
Grade	I	II	III	IV	V	I	II	III	IV	V	
0	-	-	-	-	1	2	1	2	1	1	8
1	3	1	-	-	1	3	2	4	1	2	17
2	3	-	2	1	1	1	2	1	1	1	13
3	-	1	-	1	-	1	-	-	-	-	3
4	1	-	-	1	2	-	1	-	1	3	9
Totals:	7	2	2	3	5	7	6	7	4	7	50

Medical Cases

Retinal	Males					Females					Total
Grade	I	II	III	IV	V	I	II	III	IV	V	
0	3	-	-	-	-	12	5	3	-	-	23
1	2	1	-	-	-	5	1	2	2	1	14
2	3	2	1	2	-	7	3	3	-	2	23
3	-	-	2	-	1	-	2	1	1	2	9
4	-	-	1	1	11	-	-	-	1	4	18
Totals:	8	3	4	3	12	24	11	9	4	9	87

Table 13: To show the distribution of basic diastolic pressures (grades I to V) obtained during the Sodium Amytal sedation test, correlated with retinal grade.

FIG. VII



<u>Fig. VII:</u> To show the percentage distribution among the five grades of diastolic pressure level in the <u>Sodium Amytal test</u> of the 50 surgical and 87 medical cases thus tested during the preliminary examination.

they return to normal.

Hines and Brown found three types of reaction to this test:

1. Normal: D.B.P. rises by 5-10 mm Hg.
   S.B.P. " " 10-15 mm.Hg.
2. "Hyper-reactor": D.B.P. rises by 15-20 mm Hg. or more
   S.B.P. " " 20-30 mm Hg. " "
3. Established hypertension: D.B.P. rises by 25 mm Hg.
   S.B.P. " " 30 " "

Of the group termed "hyper reactors" a significantly larger proportion were found by Hines and Brown to develop established hypertension than that of the "normal" group, and accordingly the test has been considered to have some prognostic value. Be that as it may, it gives a measure of the upward range or "ceiling" of the individual's diastolic pressure and thus forms a useful complement to the sedation test in estimating the total range of the diastolic pressure in any one individual.

Only 24 of the surgical group were given this test in the pre-operative period, the maximum diastolic pressures so achieved ranging from 108 to 170 mm Hg. Their distribution is as follows:

Maximum D.B.P. level	No. of cases	Percentage
100-109 mm Hg.	1	4.2
110-119 " "	0	-
120-129 " "	1	4.2
130-139 " "	5	20.7
140-149 " "	4	16.7
150-159 " "	4	16.7
160-169 " "	4	16.7
170-179 " "	5	20.8
Total	24	100%

C. Postural Blood Pressure Test: Tilting Table

Lastly we must mention the tilting-table test, which ought to have played a larger part in the pre-treatment investigation of our series but was not available for every patient.

Only 16 surgical and no medical cases were tested thus during their initial period of observation.

The test is designed to evaluate the effect of sudden change of position upon the blood pressure and pulse rate. When a normal individual, lying horizontally, is suddenly moved into the upright position, certain circulatory adjustments take place causing slight changes to occur in blood pressure and pulse rate. The systolic pressure falls by about 5 mm Hg., the diastolic pressures rises by 5-10 mm Hg. and the pulse rate as a rule increased by about 10-12 beats per minute.

Hypertensive individuals show much the same type of reaction, but the diastolic rise increases to 10-15 mm Hg. or even more.

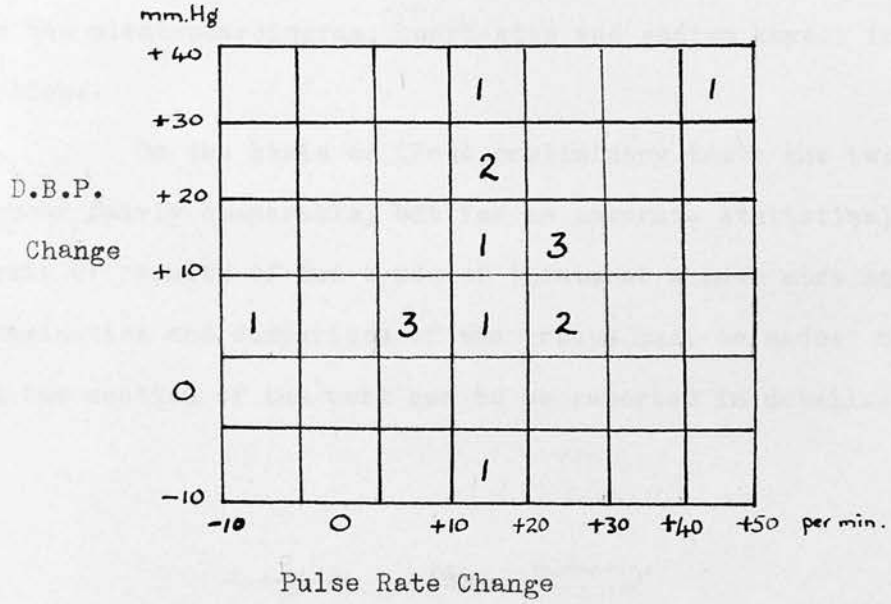
The 16 surgical patients who were tested pre-operatively gave the result which is seen in Fig. VIII.

The diastolic pressure response to tilting into the head-up position ranged from -5 mm Hg. to 40 mm Hg., the mean change being 14 mm Hg. and the median 10 mm Hg.

The pulse rate responded by a range of change from -4 per minute to 44 per minute, the mean change being 17.6 per minute, and the median change 18 per minute.

FIG. VIII

<u>Fig. VIII</u>: To show pre-operatively (for 16 surgical cases) the relation of <u>change</u> in diastolic pressure to <u>change</u> in pulse rate noted during tilting from the horizontal to the erect position.



(Range of diastolic pressure (D.B.P.) response to tilting -5 mm Hg. to 40 mm Hg.

<u>D.B.P.</u> (Mean change in D.B.P.: 14 mm Hg.

(Median " " " : 10 " "

(Range of change in pulse rate: -4 to 44 per min.

<u>Pulse</u> (Mean " " " " : 17.6 per min.

(Median " " " " : 18 per min.

Summary of the foregoing report on the material of the investigation:

We have now reported on the performance of all our medical and surgical cases in their various pre-treatment investigations.

The surgical group had more favourable results in cardiac and renal efficiency tests, but were definitely poorer as regards basal waking diastolic pressure and severity of symptoms.

There was no significant difference between the groups in the electrocardiogram, heart-size and sodium amytal investigations.

On the basis of these preliminary tests the two groups appear fairly comparable, but for an accurate statistical analysis of results of two types of treatment a much more searching examination and comparison of the groups must be made: this is the section of the work now to be reported in detail.

METHOD OF INVESTIGATION

The 151 patients described in the foregoing report of preliminary investigations, since they represented a series not specifically selected for the purpose of a statistical analysis, had now to be arranged into comparable groups of surgical and medical cases on the basis of the findings at the initial examination.

This was done in the following way: the surgical cases were first divided into two groups according to sex, since it has been noted that the prognosis of hypertension is different in the two sexes, males (other things being equal) being more severely affected than females (58). Then each of these two surgical groups was subdivided into five smaller groups on the basis of retinal grading (i.e. 0, 1, 2, 3, 4.)

These groups were still further subdivided into, for example F. 1A, F. 1B, or M. 2A, M. 2B and so on, keeping not only the sex and retinal grade constant but also one other factor, e.g. cardiac or renal efficiency.

This procedure resulted in all the cases falling into 19 groups with the criteria shown in Table 14.

Next, each "medical" patient's initial examination results were carefully scrutinised and the individual placed alongside the surgical group which he best fitted. Those medical cases who fitted exactly were termed "first-class comparisons"; those who fitted well but deviated perhaps in one degree in any criterion other than retinal grade were called "second-class comparisons"; those who fitted less well but better/

TABLE 14

Sex	Group	Retinal grade	Cardiac grade	Renal grade
F.	1A	O	A	A
	1B	O	A	B
	1C	O	B	A
	2A	I	A	A
	2B	I	A	B
	2C	I	B	A
	3A	II	A	A
	3B	II	B	A
	4	III	A-B	B
	5A	IV	B	B
	5B	IV	C	C
M.	1	O	A	A-B
	2	I	A	A
	3A	II	A	A-B
	3B	II	B	A-B
	4	III	B	B
	5A	IV	A	B
	5B	IV	B	B
	5C	IV	C	C

Table 14: To show the preliminary grouping of surgical cases in the process of building up the "matched groups".

better in that group than in any other were graded "third-class comparisons" and were excluded from the statistical analysis of results.

Finally there emerged from this apparent confusion 8 male and 11 female groups consisting of surgical and medical cases matched as accurately as possible on the basis of their pre-treatment tests, the addition of the medical cases causing no alteration whatever in the description of the group standard given above, since the "third-class comparisons", who might have disturbed the homogeneity of a group, had been discarded. These third class comparisons numbered in all 22; they consisted of 4 males, all benign cases, and 18 females, 17 benign and 1 malignant. Details of these discarded cases will be appended at the end of this paper.

The final numbers and constituents of each group were as shown in Table 15.

This procedure of "matched groups" is one which should meet the requirements stated by R.H. Smithwick in 1948 (54) when he writes: "Further comparisons of surgically and non-surgically treated cases divided into similar sub-groups in which the most important variables are held constant, is desirable. Until this can bd done the influence and relative merits of various therapeutic measures upon the course of hypertensive vascular disease cannot be evaluated with certainty."

Having classified every patient according to the method just described with respect to his initial findings in symptom-severity, diastolic pressure, retinal, cardiac and renal grades, (with the additional items of electrocardiogram, heart-

size/

TABLE 15

Sex	Group	No. of Surgical cases	Medical 1st Class	Medical 2nd Class	Medical 3rd Class
M.	1	3	3	-	-
	2	5	1	2	-
	3A	6	1	1	-
	3B	2	2	1	3
	4	2	2	-	1
	5A	3	4	3	-
	5B	1	2	-	-
	5C	1	1	4	-
Totals:		23	16	11	4
F.	1A	3	4	-	-
	1B	1	3	3	4
	1C	3	1	4	2
	2A	2	2	-	-
	2B	4	2	2	-
	2C	7	3	2	2
	3A	3	3	2	-
	3B	3	3	4	6
	4	1	2	2	3
	5A	4	3	-	-
	5B	1	2	-	1
Totals:		32	28	19	18

Table 15: To show the final constitution of each whole group (composed of surgical cases plus similar medical cases of three grades of comparison) which will be used for the statistical analysis of results. The third class medical comparison will not be thus employed and hereafter are disregarded

size and amytal test results) the next step was to obtain a record of the same observations repeated at a suitable interval after treatment had commenced, in the case of the medical group, or after sympathectomy in the group surgically treated.

The choice of the follow-up interval was of some importance. It was desirable to use as long a period as possible to give ample time for the results of treatment to become manifest. A long interval also helps to reduce bias, by eliminating from the analysis all patients who die soon after the initial examination and who therefore may have been too ill to benefit from treatment.

On the other hand, increasing the interval involves the omission from the comparison of the most recent cases. The best compromise was to base the main comparison on the difference between the initial finding and that at the examination most nearly coinciding with the first anniversary of the commencement of treatment.

Severity of symptoms and cardiac and renal efficiency have been graded on an A.B.C.D. scale and an arbitrary value of unity has been given to each successive step; retinal grades also (0, I, II, III, IV) have a value of unity between one grade and the next; diastolic blood pressure differences were of course given quantitatively in mm Hg.

In each group the average change in the grading according to each criterion was calculated for surgically and medically treated cases, and the probability that the observed difference (if any) might be due to chance. The combined probability that/

that all the differences with respect to treatment might be chance effects was then calculated. Where this probability is less than 1:20 the treatments are taken as giving significantly different results.

We shall now present the findings at the selected interval of twelve months after the start of treatment in the medical, and after the completion of sympathectomy in the surgical cases.

Each of the factors dealt with in the preliminary investigation will be re-examined in turn. For each, the pre- and post-treatment results of surgical and medical cases will be presented graphically, with an estimation of the percentage of improved, deteriorated or unchanged cases resulting from treatment. This will be followed by the results of the statistical work on the matched groups, which, by virtue of the careful assembling of the group constituents, will be the final verdict.

Finally in each section a considered opinion will be given as to which type of treatment has proved more beneficial in that particular instance.

RESULTS OF TREATMENT

Before presenting and comparing the results of the two methods of treatment it must be made clear that from this point onwards the phrase "medical cases" refers to first and second class comparisons only (see pp.28-29), the third class comparisons having been discarded.

The medical cases from now on, therefore, number only 74, 22 of the original 96 having been regarded as "third class". The discarding of 22 cases will necessarily involve an alteration in the pre-treatment actual and percentage distribution of the medical cases in the various tests, but fresh tables will show these new distributions, using only first and second class comparisons.

A. The Effect of the Two Forms of Treatment on Various Factors Tested at the Initial Examination

1. The effect of surgical and medical treatment on subjective symptoms.

Tables 16 and 17 show respectively the pre- and post-treatment symptom-grade distribution of both surgical and medical cases, and Figs. IX and X the pre- and post-treatment percentages of surgical and medical cases in each symptom grade. Patients graded D have died. 8 surgical and 12 medical cases were not examined at approximately the 12-month follow-up period; their results would therefore depend on their own recollection and are not accepted as reliable. These are graded "N.K." (not known) in/

TABLE 16

Surgical Cases

Retinal Grade	Males			Females			Total
	A	B	C	A	B	C	
0	-	-	3	-	1	6	10
1	-	1	4	-	-	13	18
2	-	-	8	-	-	6	14
3	-	-	2	-	-	1	3
4	-	-	5	-	-	5	10
Totals:	-	1	22	-	1	31	55

Medical Cases

Retinal Grade	Males			Females			Total
	A	B	C	A	B	C	
0	-	3	-	-	10	5	18
1	-	1	2	-	2	9	14
2	-	1	4	-	4	8	17
3	-	1	1	-	-	4	6
4	-	1	13	-	-	5	19
Totals:	-	7	20	-	16	31	74

Table 16: To show the pre-treatment distribution of surgical and medical cases over the grades of symptoms, correlated with their retinal grades.

TABLE 17

Surgical Cases

Retinal Grade	Males A	Males B	Males C	Males D	Males NK	Females A	Females B	Females C	Females D	Females NK	Total
0	-	2	1	-	-	5	2	-	-	-	10
1	4	-	-	-	-	4	2	2	-	-	12
2	6	1	-	-	-	2	2	1	-	-	12
3	1	1	-	-	-	-	-	1	-	-	3
4	3	-	1	1	-	2	3	-	-	-	10
										8	
Totals:	14	4	2	1		13	9	4	-	8	47
							8 " NK "				8
											55

Medical Cases

Retinal Grade	Males A	Males B	Males C	Males D	Females A	Females B	Females C	Females D	NK	Total
0	-	2	-	-	3	5	2	-		12
1	1	1	1	-	1	3	3	-		10
2	-	4	1	-	1	6	4	-		16
3	1	4	-	1	1	-	1	1		6
4	-	-	1	13	-	-	-	5		19
									12	
Totals:	2	7	3	14	6	14	10	6		62
							12 " NK "			12
										74

Table 17: To show the post-treatment distribution of surgical and medical cases over the various symptom grades, in relation to their retinal grading. This table should be studied in conjunction with Table 16 (NK = not known)

FIG. IX Before Treatment

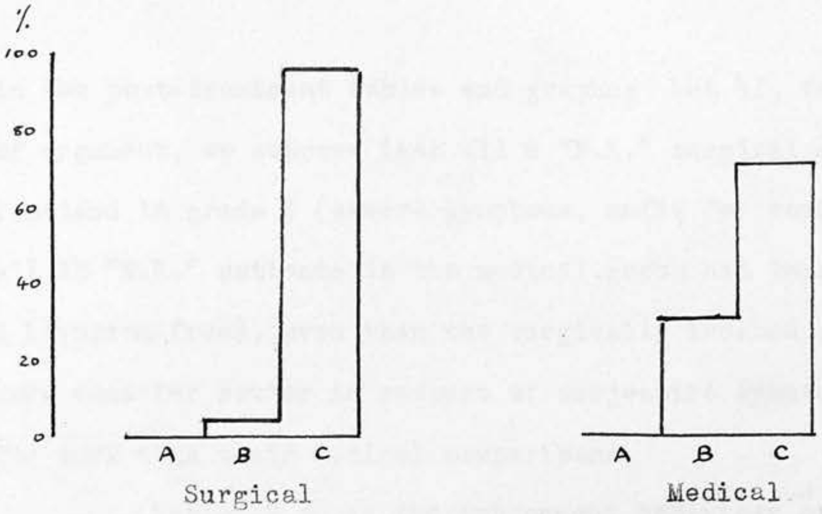
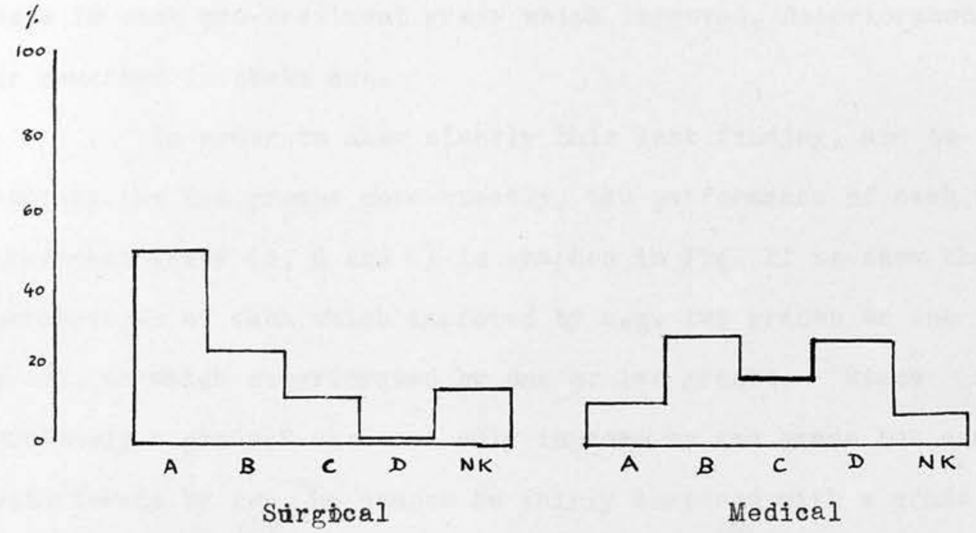


FIG. X After Treatment



Figs. IX and X: To show the change after treatment in the percentage distribution over the symptom-grades for 55 surgical and 74 medical cases in the post-treatment tables and graphs; but if, for the sake of argument, we suppose that all 8 "N.K." surgical cases had remained in grade C (severe symptoms, unfit for work) and that all 12 "N.K." patients in the medical group had improved to Grade A (symptom-free), even then the surgically treated cases would have done far better in respect of subjective symptoms and fitness for work than their medical comparisons.

Table 18 shows the subsequent behaviour of each pre-treatment grade in both surgical and medical cases at the 12 months follow-up, and in Table 19 there is set out the percentages in each pre-treatment grade which improved, deteriorated or remained in statu quo.

In order to show clearly this last finding, and to compare the two groups more exactly, the performance of each pre-treatment grade (A, B and C) is graphed in Fig. XI to show the percentages of each which improved by e.g. two grades or one grade, or which deteriorated by one or two grades. Since obviously a grade-B case can only improve by one grade but can deteriorate by two, he cannot be fairly compared with a grade C case who can only deteriorate by one grade but can improve by two grades. Hence the separation of the pre-treatment grades, and comparison of surgical and medical groups step by step, grade A with grade A, B with B and so on. Fig. XI shows clearly the much greater improvement achieved by those cases treated surgically, especially in the case of pre-treatment grade C.

If all the malignant cases are removed from both surgical and medical groups (and they are responsible for most of the deaths in the "medical" group) and if we consider only the

benign/

TABLE 18

Surgical Cases

Pre-treatment Grade	No. of cases	Post-treatment Symptom Grades					Total
		A	B	C	D	NK	
A	-	-	-	-	-	-	-
B	2	2	-	-	-	-	2
C	53	25	13	6	1	8	53
Totals:	55	27	13	6	1	8	55
	%	44.1	23.6	10.9	1.8	14.6	100%

Medical Cases

Pre-treatment Grade	No. of cases	Post-treatment Symptom Grades					Total
		A	B	C	D	NK	
A	-	-	-	-	-	-	-
B	23	7	12	-	1	3	23
C	51	1	9	13	19	9	51
Totals:	74	8	21	13	20	12	74
	%	10.8	28.4	17.5	27.0	16.3	100%

Table 18: To show the subsequent fate (at 12 months after the start of medical treatment or after operation) of the individuals classed as A, B or C respectively in the pre-treatment symptom-grading.

(NK = not known)

TABLE 19

Surgical Cases

Pre-treatment		Post-treatment						
Symptoms Grade	No. of cases	Improved		No change	Deteriorated		N.K.	Total
		++	+		-	=		
A	-	-	-	-	-	-	-	-
B	2	-	2	-	-	-	-	2
C	53	25	13	6	1	-	8	53
Totals:	55	25	15	6	1	-	8	55

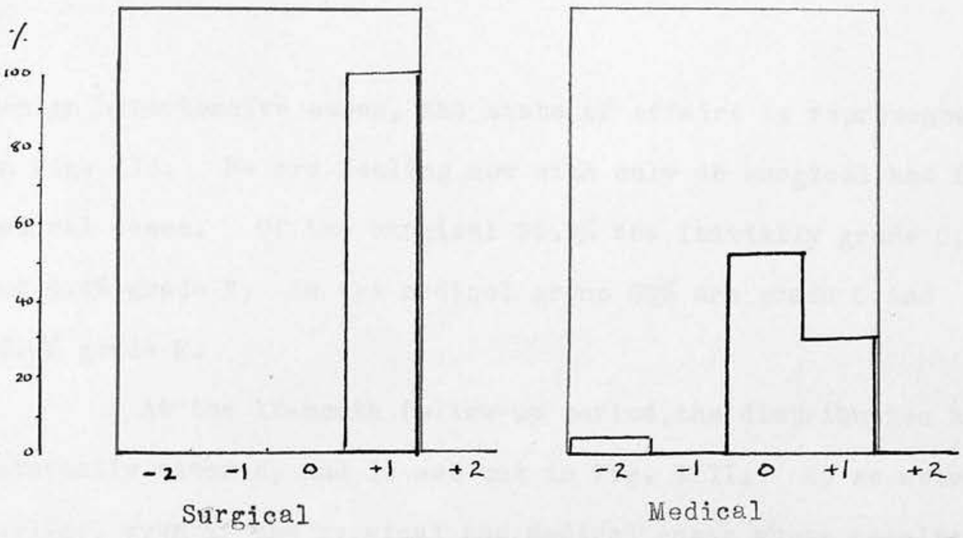
Medical Cases

Pre-treatment		Post-treatment						
Symptoms Grade	No. of cases	Improved		No change	Deteriorated		N.K.	Total
		++	+		-	=		
A	-	-	-	-	-	-	-	-
B	23	-	7	12	-	1	3	23
C	51	1	9	13	19	-	9	51
Totals:	74	1	16	25	19	1	12	74

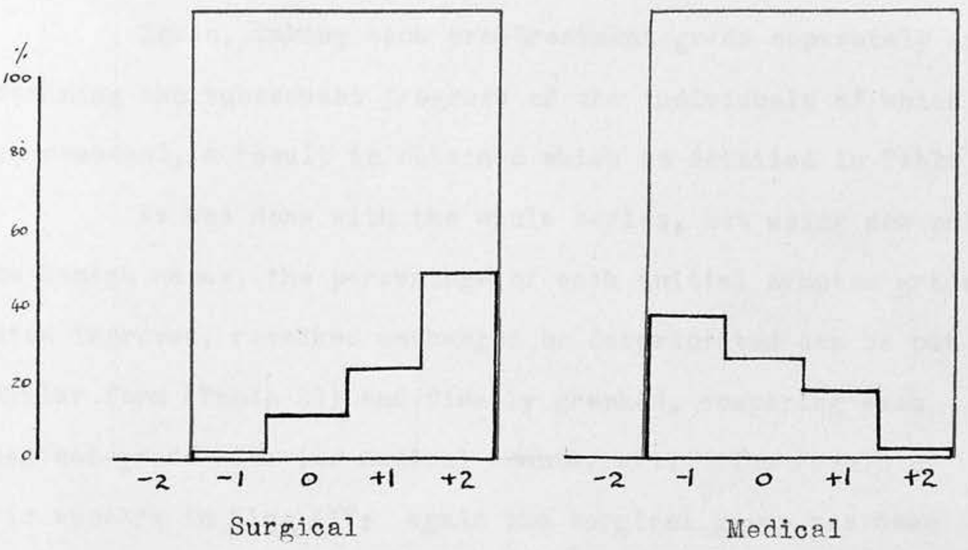
Table 19: To show the number of persons of each pre-treatment symptom grade who improved(and by how many grades), deteriorated (and by how many grades) or remained in statu quo

(++ means "improved by 2 grades") and (= means "deteriorated by 2 grades")
(+ " " " 1 ") (- " " " " 1 grade)

FIG. XI



(a) Pre-treatment Grade B.



(b) Pre-treatment Grade C.

Fig. XI: To show the percentage of each of the pre-treatment symptom-grades B and C (there were no A cases) who improved, deteriorated, or remained unchanged, at the 12-months follow-up.

Key to Diagram;

+1, +2 denote improvement by one or two grades respectively
-1, -2 " deterioration" " " " "
0 denotes no change

The lines in red indicate the maximum change in either direction through which a patient in this pre-treatment grade can change.

benign hypertensive cases, the state of affairs is represented in Fig. XII. We are dealing now with only 45 surgical and 55 medical cases. Of the surgical 95.6% are initially grade C, and 4.4% grade B; in the medical group 60% are grade C and 40.0% grade B.

At the 12-month follow-up period, the distribution has materially altered, and is set out in Fig. XIII. As we noted earlier, even if the surgical and medical cases whose results are not known are added to the most severe surgical or the mildest medical grade respectively the surgical cases would again appear to have achieved the greatest benefit.

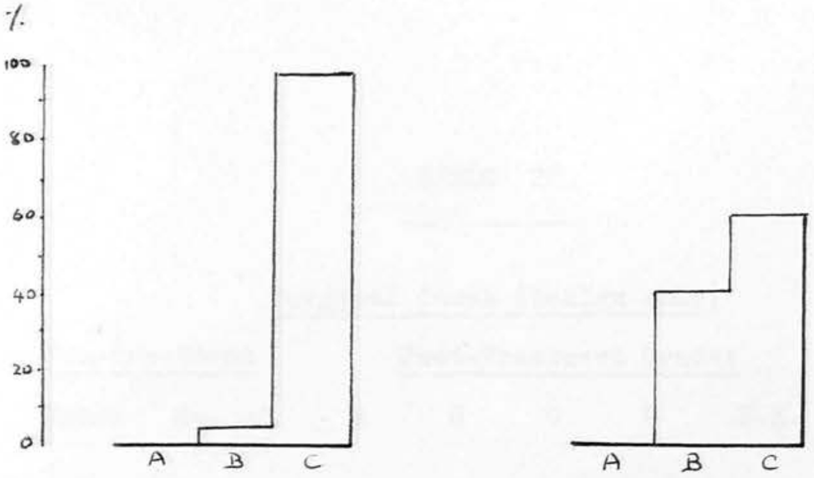
Again, taking each pre-treatment grade separately and examining the subsequent progress of the individuals of which it was composed, a result is obtained which is detailed in Table 20.

As was done with the whole series, but using now only the benign cases, the percentage of each initial symptom grade which improved, remained unchanged or deteriorated can be put in tabular form (Table 21) and finally graphed, comparing each surgical grade with its medical counterpart. The result of this appears in Fig. XIV; again the surgical group has done better, even without the bias against medical treatment provided by the malignant medical cases.

Having examined the pre- and post-treatment figures and compared the groups as whole units we must now proceed to the more exact statistical work, using the matched groups, in order to check our first more rough-and-ready findings.

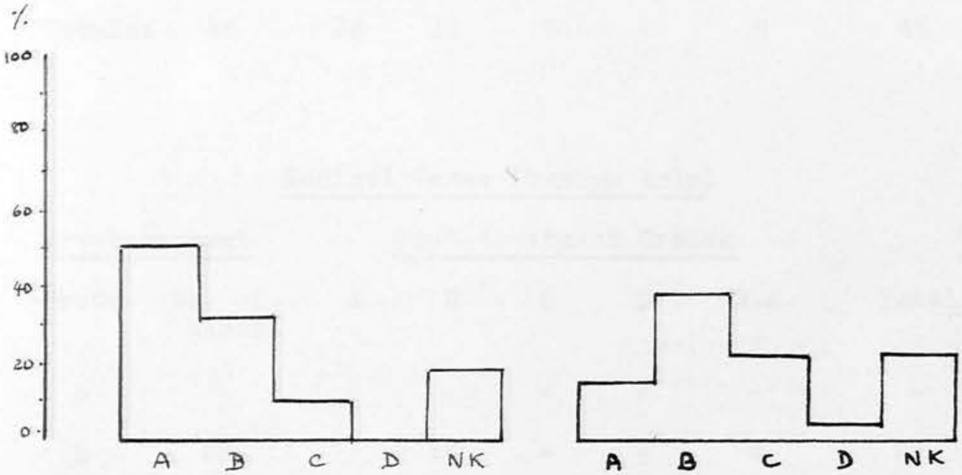
In the statistical analysis also we find that the surgical/

FIG. XII Before Treatment



Surgical Medical

FIG. XIII After Treatment



Surgical Medical

Figs. XII and XIII: To show the change after treatment in the symptom-grading of the benign cases, (45 surgical and 55 medical). Cf. Figs. IX and X

TABLE 20

Surgical Cases (benign only)

Pre-treatment		Post-Treatment Grades					
Grade	No. of cases	A	B	C	D	N.K.	Total
A	-	-	-	-	-	-	-
B	2	2	-	-	-	-	2
C	43	21	11	5	-	6	43
Totals:	45	23	11	5	-	6	45

Medical Cases (benign only)

Pre-treatment		Post-treatment Grades					
Grade	No. of cases	A	B	C	D	N.K.	Total
A	-	-	-	-	-	-	-
B	22	7	12	-	-	3	22
C	33	1	9	13	1	9	33
Totals:	55	8	21	13	1	12	55

Table 20: To show the subsequent fate of each initial symptom-grade in both surgical and medical groups, using the benign cases only.

(NK = not known)

TABLE 21

Surgical Cases (benign only)

Pre-treatment		Post-treatment						
Symptoms Grade	No. of cases	Improved		No change	Deteriorated		N.K.	Total
		++	+		-	=		
A	-	-	-	-	-	-	-	-
B	2	-	2	-	-	-	-	2
C	43	21	11	5	-	-	6	43
Totals:	45	21	13	5	-	-	6	45

Medical Cases (benign only)

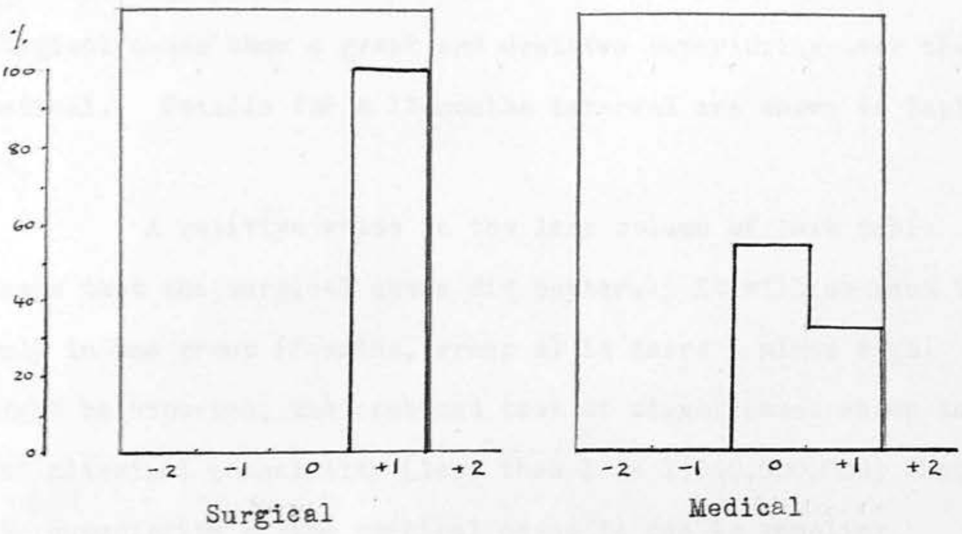
Pre-treatment		Post-treatment						
Symptoms Grade	No. of cases	Improved		No change	Deteriorated		N.K.	Total
		++	+		-	=		
A	-	-	-	-	-	-	-	-
B	22	-	7	12	-	-	3	22
C	33	1	9	13	1	-	9	33

Table 20: To show the number of individuals of each initial symptom grade who improved, deteriorated or remained unchanged. This table provides the material on which Fig. XIV is based.

(NK = not known)

FIG. XIV

(a) Pre-treatment Grade B



(b) Pre-treatment Grade C

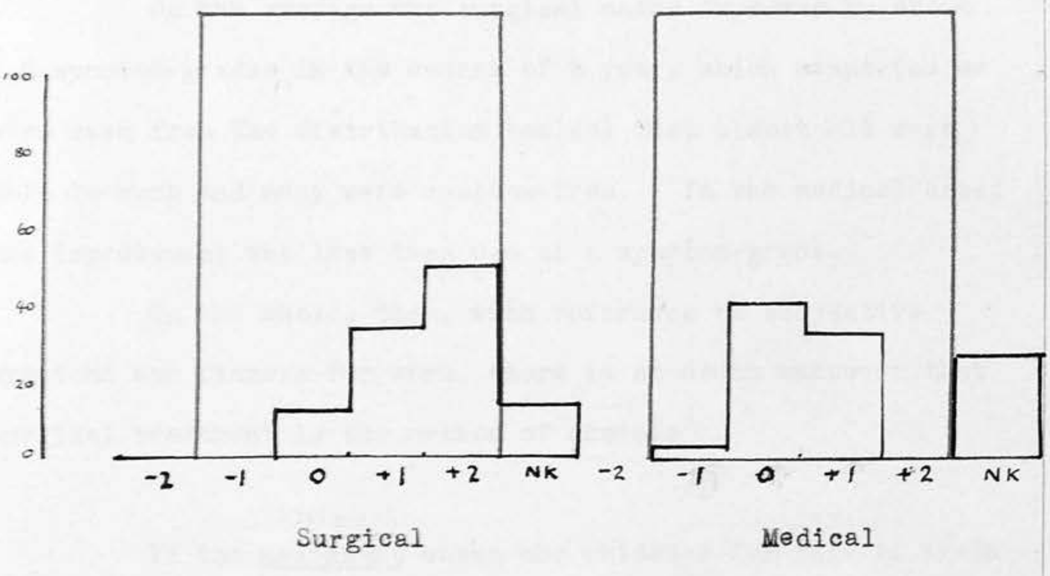


Fig. XIV: To show the percentage change after treatment in each of the pre-treatment symptom-grades B and C, as regards the benign cases only. (There were no A cases).

surgical cases show a great and decisive superiority over the medical. Details for a 12-months interval are shown in Table 22.

A positive value in the last column of this table means that the surgical cases did better. It will be seen that only in one group (Females, group 4) is there a minus sign. As might be expected, the combined test of significance shows an infinitesimal probability (less than 1 in 1,000,000,000) that the superiority of the surgical cases is due to sampling fluctuation.

On the average the surgical cases improved by about 1.4 symptom-grades in the course of a year, which meant (as we have seen from the distribution tables) that almost all were able to work and many were symptom-free. In the medical cases the improvement was less than 0.4 of a symptom-grade.

On the whole, then, with reference to subjective symptoms and fitness for work, there is no doubt whatever that surgical treatment is the method of choice.

In the <u>malignant</u> cases the evidence for this is again overwhelming, although admittedly our series is small. As will be demonstrated later, in a non-operated malignant hypertensive case, the average expectation of life is less than three months; in our surgical series on the other hand, at the time of the 12-months follow-up investigation, 7 out of 10 had derived great benefit from the operation and were fit for work, 5 of the 7 being symptom-free.

Considering for a moment the long-term follow-up of these/

TABLE 22

Mean changes in symptom-grade after 12 months

Sex	Group	Surgical cases		Medical Cases		Difference between Means
		No.	Mean improvement	No.	Mean improvement	
M	1	3	0.67 grade	0	-	-
	2	4	2.00 "	2	0.5 grade	1.5
	3A	5	1.8 "	2	0.5 "	1.3
	3B	2	2.00 "	3	0.67 "	1.33
	4	2	1.50 "	1	1.00 "	0.50
	5A	3	1.33 "	0	-	-
	5B	1	2.00 "	1	-1.00 "	3.00
F.	1A	3	1.33 grade	4	0.50 grade	0.83
	1B	1	1.00 "	3	0.33 "	0.67
	1C	3	2.00 "	3	0.00 "	2.00
	2A	1	2.00 "	1	1.00 "	1.00
	2B	3	1.00 "	4	0.25 "	0.75
	2C	5	1.20 "	2	0.50 "	0.70
	3A	3	0.67 "	5	0.20 "	0.47
	3B	2	2.00 "	6	0.33 "	1.67
	4	1	0.00 "	2	1.00 "	- 1.00
	5A	4	1.50 "	1	0.00 "	1.50
	5B	1	1.00 "	0	-	-
Totals:		47	aver. 1.43	42	aver. 0.38	1.05

these cases we find that the surgical malignant hypertensive patients have been observed over considerable periods of time, the details of these patients being set out in Table 23.

Turning now to the medically-treated malignant group, we find that the 19 cases in this series all remained in category C and died at an average of 2.8 months after first coming under observation; these were all cases comparable at the outset to their surgical counterparts in the matched groups, thus in the malignant series even more strikingly than in the benign, surgery has proved to the satisfaction of the most critical that it has more to offer than medical treatment.

3. The effect of surgical and medical treatment on the basic waking diastolic blood pressure.

As we have described earlier in this report, every patient had a basic waking blood pressure recorded during the period of the initial examination.

With the third-class medical comparisons now discarded, the distribution of these initial diastolic pressures in the two groups is set out in Fig. XV using all the cases, benign and malignant; Fig. XVI shows the distribution when benign cases alone are used.

In both graphs it appears that the surgical group has a higher percentage of individuals with diastolic pressures in the upper ranges.

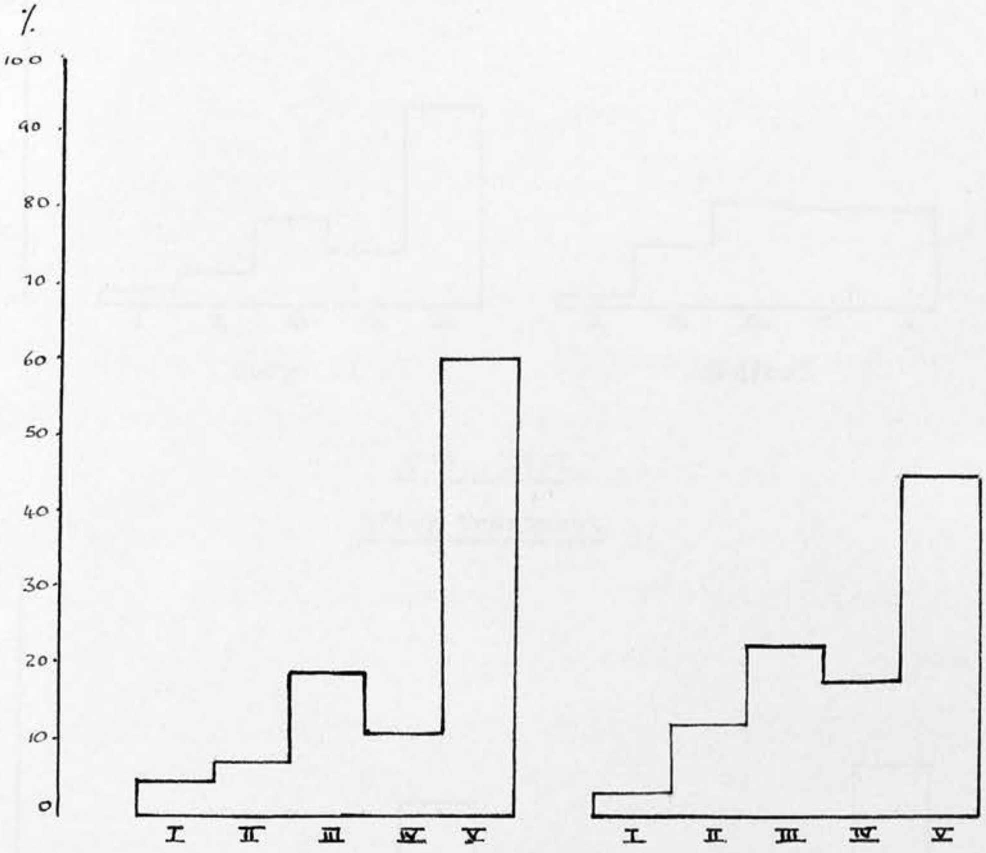
Unfortunately a number of these cases had no reliable blood-pressure reading taken at or about the 12 months follow-up period; of the 55 <u>benign</u> cases who had a reading taken at this time/

TABLE 23

Subsequent progreas of surgically treated malignant hypertensive cases, with respect to fitness for work.

Case	Sex	Age	Observed for	Remarks
1	F	36	13.5 months	Fit for work and symptom-free at 12 months but died of cerebral haemorrhage at 13.5 months
2	F	44	20 "	Fit for work. Symptom free.
3	F	45	24 "	Fit for work. Symptom free.
4	F	45	11 "	Has hemiplegia due to pre-operative cerebral haemorrhage, but can do her housework.
5	F	40	14 "	Has fairly severe symptoms still.
6	M	49	9 "	Died of renal failure
7	M	44	18 "	Symptom-free.
8	M	45	45 "	Symptom-free
9	M	60	10 "	Died of carcinoma of liver; had no recurrence of hypertensive symptoms.
10	M	45	5 "	Died of cardiac and renal failure

FIG. XV

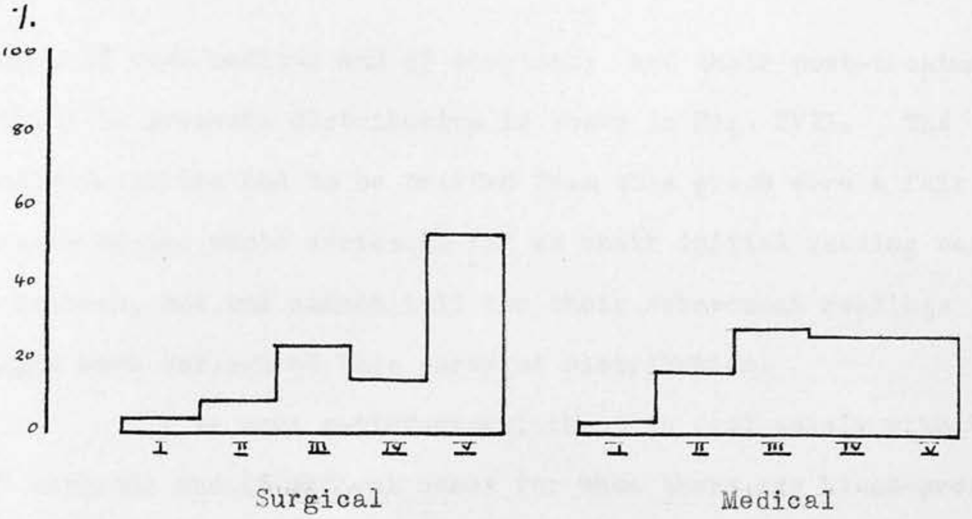


Surgical Medical

Fig. XV: To show the pre-treatment percentage distribution of surgical and medical cases, omitting third class medical comparisons, among the grades of diastolic pressure.

FIG. XVI

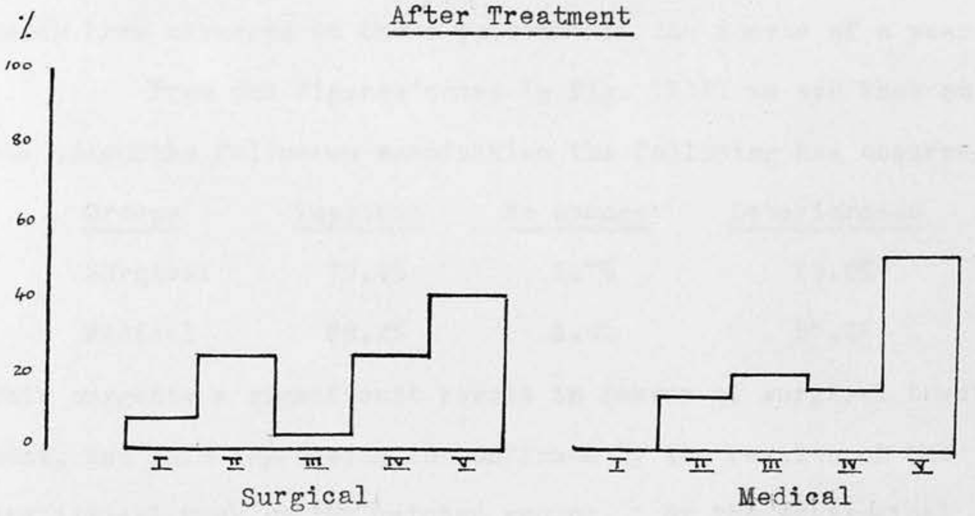
Before Treatment



Surgical Medical

FIG. XVII

After Treatment



Surgical Medical

Figs. XVI and XVII: To show the percentage distributions, before and after treatment, of both surgical and medical cases over the grades of basic diastolic pressure.

time, 28 were medical and 27 surgical; and their post-treatment diastolic pressure distribution is shown in Fig. XVII. The individuals who had to be omitted from this graph were a fair sample of the whole series as far as their initial reading was concerned, but one cannot tell how their subsequent readings might have influenced this curve of distribution.

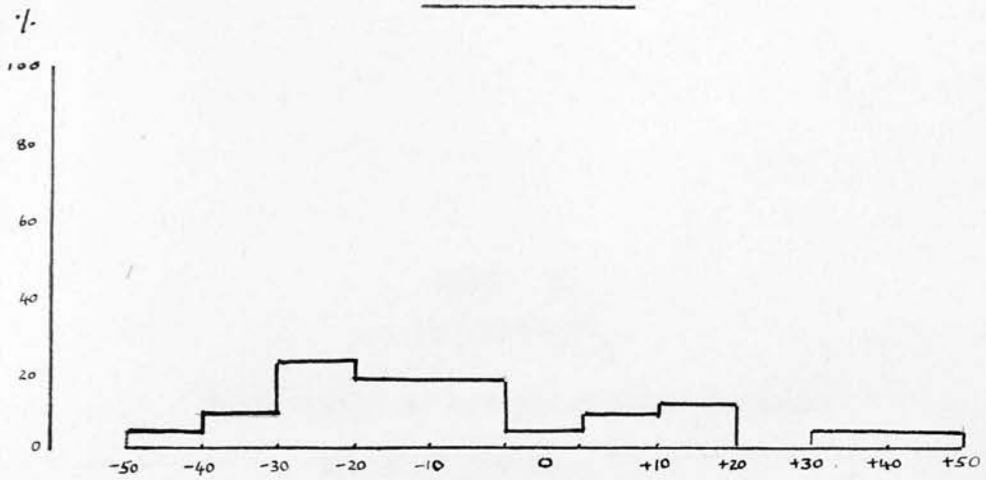
It is more satisfactory, then, to deal solely with the 27 surgical and 28 medical cases for whom there are blood-pressure readings initially and 12 months later, and Fig. XVIII shows the distribution (in percentages) of diastolic pressure <u>changes</u> which have occurred in these patients in the course of a year.

From the figures noted in Fig. XVIII we see that at the 12-months follow-up examination the following has occurred:

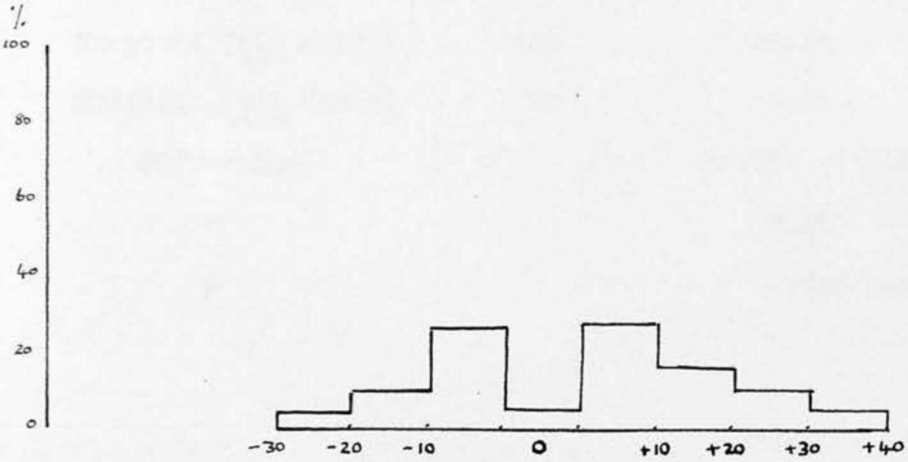
Groups	Improved	No change	Deteriorated
Surgical	70.4%	3.7%	25.9%
Medical	39.2%	3.6%	57.2%

This suggests a significant result in favour of surgical treatment, and this impression is confirmed by the results of the statistical work on the matched groups. By the statistical method, medical cases showed an average rise in diastolic blood pressure, and surgical cases an average fall, and the difference was statistically highly significant. The amount of rise or fall did not seem to vary with the severity of the case (for example it is not less in matched groups 1 or 2 and higher in 4 or 5) and it was therefore considered legitimate to pool all the surgical and all the medical cases. The means and test of significance are given in Table 24.

FIG. XVIII



Surgical



Medical

Fig. XVIII: To show the effect of treatment in 27 benign surgical and 28 benign medical cases on the basic diastolic pressure.

Key: The base-line represents post-treatment changes in D.B.P. expressed as plus or minus x mm Hg. The numbers of cases in each grade are expressed as percentages of the whole.

TABLE 24

Mean change in Diastolic Blood Pressure after 12 months.

	No.	Mean change (mm Hg.)
Surgical (all cases)	31	-8.39
Medical (all cases)	30	8.37
Difference		16.76 - 5.08
t		3.30
p		0.001 approx.

Although the changes are statistically established they are not very striking in magnitude, averaging +8.4 mm Hg. in medical and -8.4 mm Hg. in surgical cases.

If, before leaving this subject, we consider the behaviour of the malignant cases as regards diastolic pressure, we find that whereas, initially all but two of the medical cases and all the surgical were in Grade V (over 120 mm Hg.), at the end of a year 9/10 of the surgicals were still in grade V, and one had improved to grade IV, while none of the medical cases had improved up to the time of death which took place on an average about 2.8 months after the initial examination.

It makes little odds, therefore, to the diastolic pressure of the malignant case whether he is treated surgically or medically; but according to our results, on the whole, surgery is a more effective weapon in obtaining significant reduction in blood pressure, even though the reduction (as in the present series) is not dramatic.

3. The effect of surgical and medical treatment on retinal grade.

The pre-treatment distribution of both medical and surgical groups, now that the third class medical comparisons have been thrown out, appears as is shown in Table 25, and the percentage distribution of each grade, taking surgical and medical groups as ~~a~~ whole units, is set out in Fig. XIX.

If the malignant cases are excluded the percentage distribution/

TABLE 25

Initial Retinal Grades.

Retinal	Surgical Cases			Medical Cases		
Grade	Male	Female	Total	Male	Female	Total
0	3	7	10	3	15	18
1	5	13	18	3	11	14
2	8	6	14	5	12	17
3	2	1	3	2	4	6
4	5	5	10	14	5	19
Totals:	23	32	55	27	47	74

FIG. XIX

Before Treatment

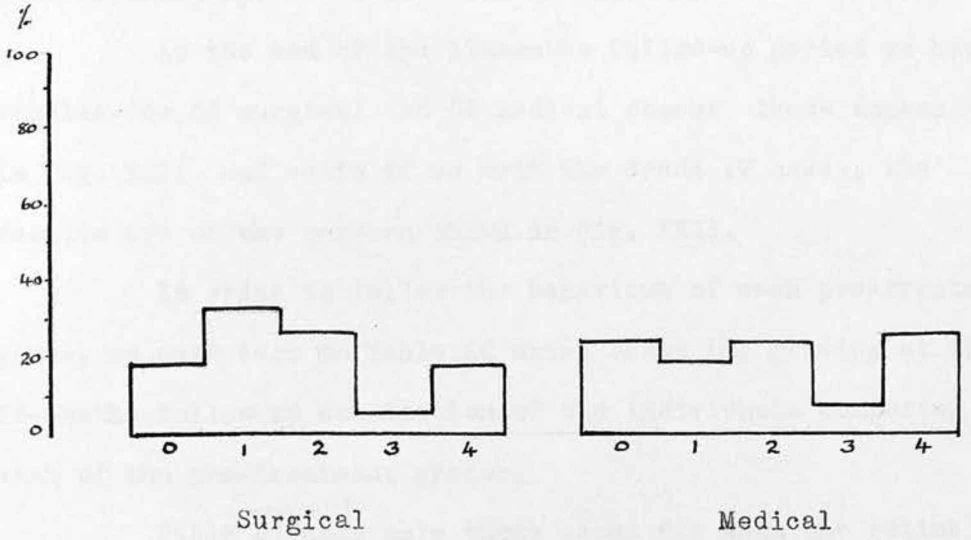
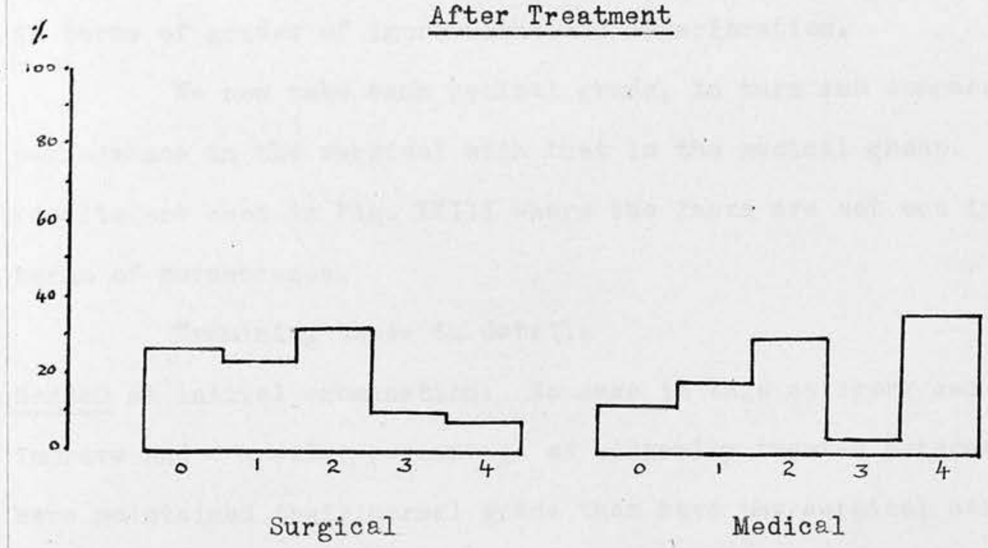


FIG. XXI

After Treatment



Figs. XIX and XXI: To show the percentage distribution of both benign and malignant cases throughout the retinal grades 0-4 before and after treatment distributions appear as is shown in Fig. XX.

At the end of the 12-months follow-up period we have results for 43 surgical and 52 medical cases: these appear as in Fig. XXI; and again if we omit the Grade IV cases, the results are of the pattern shown in Fig. XXII.

In order to follow the behaviour of each pre-treatment grade, we must turn to Table 26 which shows the grading at the 12-months follow-up examination of the individuals composing each of the pre-treatment grades.

Table 27 uses only those cases for whom the retinal grade is known with certainty at both the initial and the 12-month Follow-up examinations and expresses the changes observed in terms of grades of improvement and deterioration.

We now take each retinal grade, in turn and compare its performance in the surgical with that in the medical group. The results are seen in Fig. XXIII where the facts are set out in terms of percentages.

Examining these in detail:

Grade0 at initial examination: No case in this category can improve and a greater percentage of medically treated persons have maintained their normal grade than have the surgical cases.

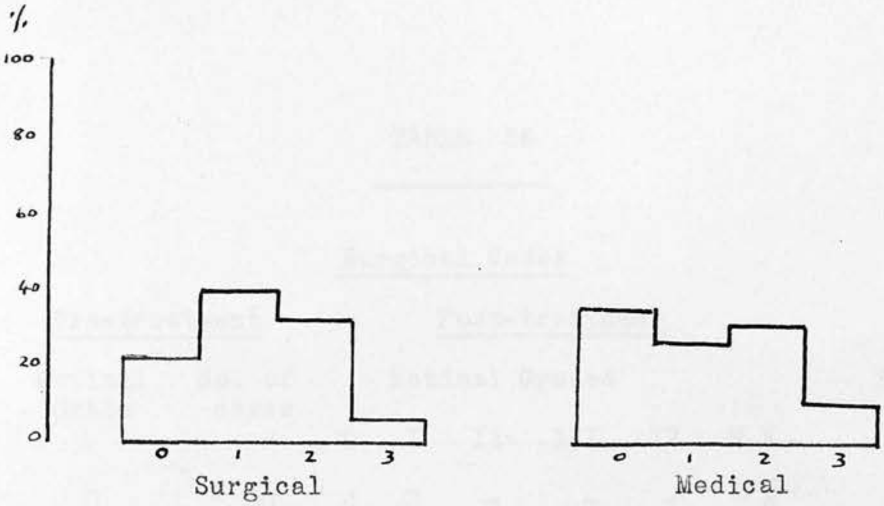
Grade I: Here the surgically treated cases have done rather better, at least half having improved by one grade.

GradeII: Again there is a very slight balance in favour of the surgical cases: 93% of the "medicals" are unchanged, whereas 25% of the surgicals have improved.

Grade III: The balance is about equal here.

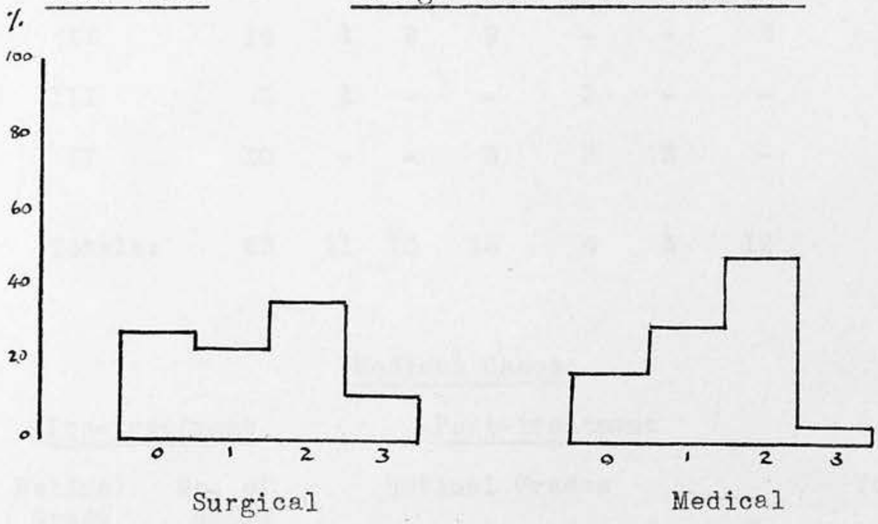
Grade IV/

FIG. XX Benign cases before Treatment



Surgical Medical

FIG. XXII Benign Cases after Treatment



Surgical Medical

Figs. XX and XXII: To show the percentage distribution of benign cases only before and after treatment throughout the retinal grades 0 - 3.

TABLE 26

Surgical Cases

Pre-treatment		Post-treatment						
Retinal Grade	No. of cases	Retinal Grades						Total
		0	I	II	III	IV	N.K.	
0	10	4	3	-	-	-	3	10
I	18	5	5	1	-	-	7	18
II	14	1	2	9	-	-	2	14
III	3	1	-	-	2	-	-	3
IV	10	-	-	5	2	3	-	10
Totals:	55	11	10	15	4	3	12	55

Medical Cases

Pre-treatment		Post-treatment						
Retinal Grade	No. of cases	Retinal Grades						Total
		0	I	II	III	IV	N.K.	
0	18	5	-	1	-	-	12	18
I	14	1	9	1	-	-	3	14
II	17	-	1	13	-	-	3	17
III	6	-	-	1	1	-	4	6
IV	19	-	-	-	-	19	-	19
Totals:	74	6	10	16	1	19	22	74

Table 26: To show the subsequent change in retinal appearance of the individuals composing the various retinal grades at the initial examination.

(NK = not known)

TABLE 27

Surgical Cases

Pre-treatment		Post-treatment							
Retinal Grade	No. of cases	Improved			No change	Deteriorated			Total
		+++	++	+		-	=	≡	
0	7	-	-	-	4	3	-	-	7
I	11	-	-	5	5	1	-	-	11
II	12	-	1	2	9	-	-	-	12
III	3	1	-	-	2	-	-	-	3
IV	10	-	5	2	3	-	-	-	10
Total	43								

Medical Cases

Pre-treatment		Post-treatment							
Retinal Grade	No. of cases	Improved			No change	Deteriorated			Total
		+++	++	+		-	=	≡	
0	6	-	-	-	5	-	1	-	6
I	11	-	-	1	9	1	-	-	11
II	14	-	-	1	13	-	-	-	14
III	2	-	-	1	1	-	-	-	2
IV	19	-	-	-	19	-	-	-	19
Total	52								

Table 27: To show, for each initial retinal grade, the post-treatment change in its constituent individuals.

FIG. XXIII

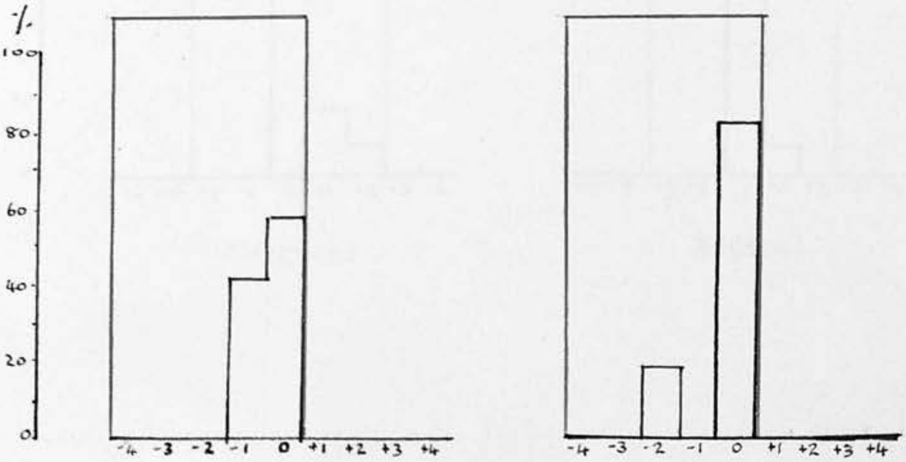
Fig. XXIII: To show the percentage of each pre-treatment retinal grade which improved, deteriorated or remained unchanged at the 12-months follow-up.

Key to Diagram

+ 1, +2 denote improvement by one or two grades respectively
-1, -2 " deterioration " " " " " "
0 denotes no change

The lines in red indicate the maximum change in either direction through which a patient in this pre-treatment grade can change.

Pre-treatment normal retina

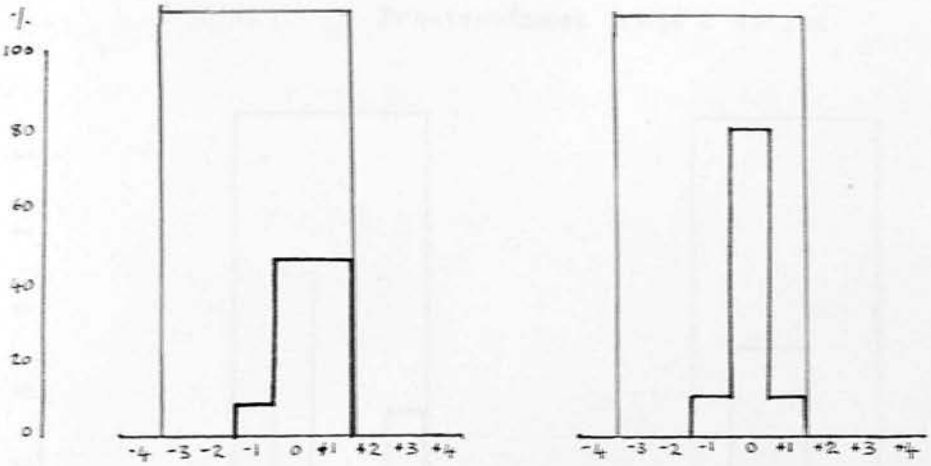


Surgical

Medical

FIG. XXIII (cont.)

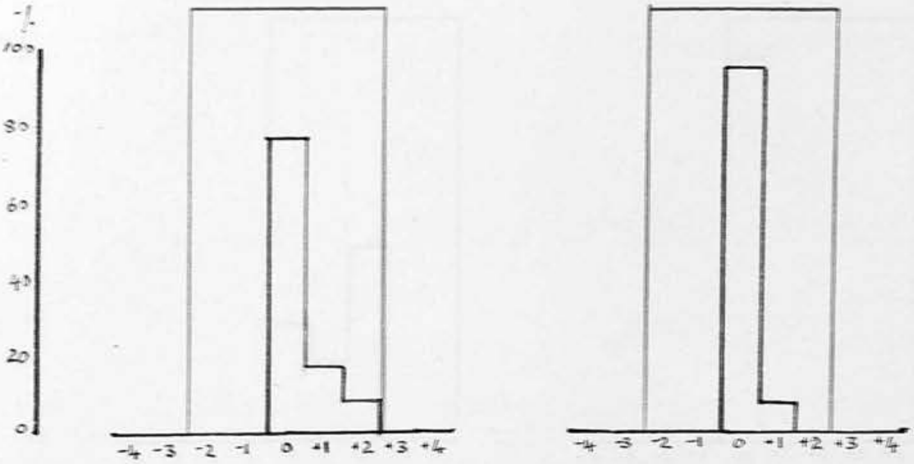
Pre-treatment Grade 1 retina



Surgical

Medical

Pre-treatment Grade 2 retina

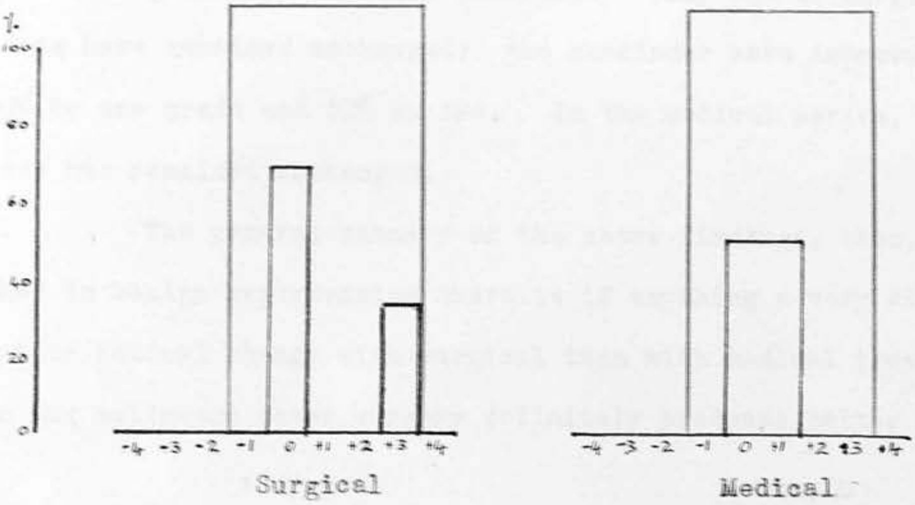


Surgical

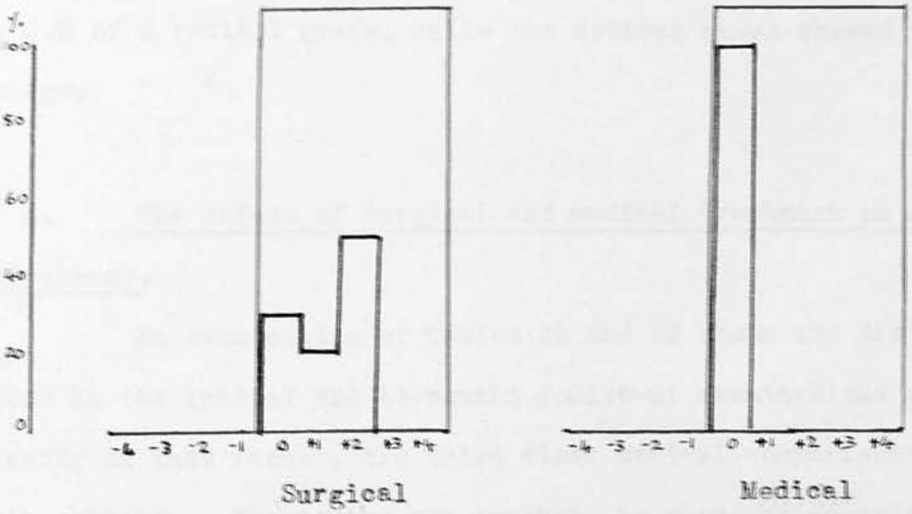
Medical

FIG. XXIII (cont.)

Pre-treatment Grade 3 Retina



Pre-treatment Grade 4 Retina



Grade IV: It is in this grade above all that surgery shows itself of greater value than medicine. Only 30% of surgical cases have remained unchanged; the remainder have improved, 20% by one grade and 50% by two. In the medical series, every case has remained unchanged.

The general summary of the above findings, then, is that in benign hypertension there is if anything a very slightly better retinal change with surgical than with medical treatment,; in the malignant cases surgery definitely produces better results.

In the statistical analysis, using the matched groups (and taking benign and malignant together) there is also a difference in favour of the surgical cases which is just significant. On the average the surgical cases improved in 12 months by 0.5 of a retinal grade, while the medical cases showed no change.

4. The effect of surgical and medical treatment on cardiac efficiency.

An examination of Tables 28 and 29 shows the distributions at the initial and 12-months follow-up examinations of the grading in this factor, the third class medical comparisons having been omitted. The tables are arranged to show the correlation with the severity of the hypertension as estimated by retinal grade.

A graphical representation of the percentage distribution at these two examinations is shown in Fig. XXIV (initial examination)/

TABLE 28

Surgical Cases

	Males				Females				
Retinal Grade	A	B	C	D	A	B	C	D	Total
0	2	1	-	-	4	3	-	-	10
I	5	-	-	-	6	7	-	-	18
II	6	2	-	-	3	3	-	-	14
III	-	1	1	-	-	1	-	-	3
IV	4	-	-	-	1	3	-	1	10
Totals:	17	4	1	1	14	17	-	1	55

Medical Cases

	Males				Females				
Retinal Grade	A	B	C	D	A	B	C	D	Total
0	2	1	-	-	10	4	1	-	18
I	1	2	-	-	6	3	2	-	14
II	2	-	3	-	5	6	1	-	17
III	1	1	-	-	2	2	-	-	6
IV	5	2	2	5	-	2	2	1	19
Totals:	11	6	5	5	23	17	6	1	74

Table 28: To show the initial distribution of cardiac efficiency grading in relation to retinal grading for the two groups, surgical and medical.

TABLE 29

Surgical Cases

	Males					Females					
Retinal Grade	A	B	C	D	NK	A	B	C	D	NK	Total
0	2	-	1	-	-	3	4	-	-	-	10
I	3	1	-	-	1	4	3	2	-	4	18
II	4	2	1	-	1	4	1	-	-	1	14
III	1	1	-	-	-	1	-	-	-	-	3
IV	1	3	-	-	1	1	3	1	-	-	10
Totals:	11	7	2	-	3	13	11	3	-	5	55

Medical Cases

	Males					Females					
Retinal Grade	A	B	C	D	NK	A	B	C	D	NK	Total
0	-	-	-	-	3	9	3	1	-	2	18
I	1	1	-	-	1	4	3	1	3	-	14
II	2	3	-	-	-	3	7	-	-	2	17
III	1	-	-	-	1	-	1	-	3	-	6
IV	-	-	-	14	-	-	-	3	2	-	19
Totals:	4	4	-	14	5	16	14	5	8	4	74

Table 29: To show the distribution of cardiac efficiency grades, in relation to retinal grading, at the 12 month follow-up examination.

(N.K. means "not known".)

FIG. XXIV

Before treatment, all cases

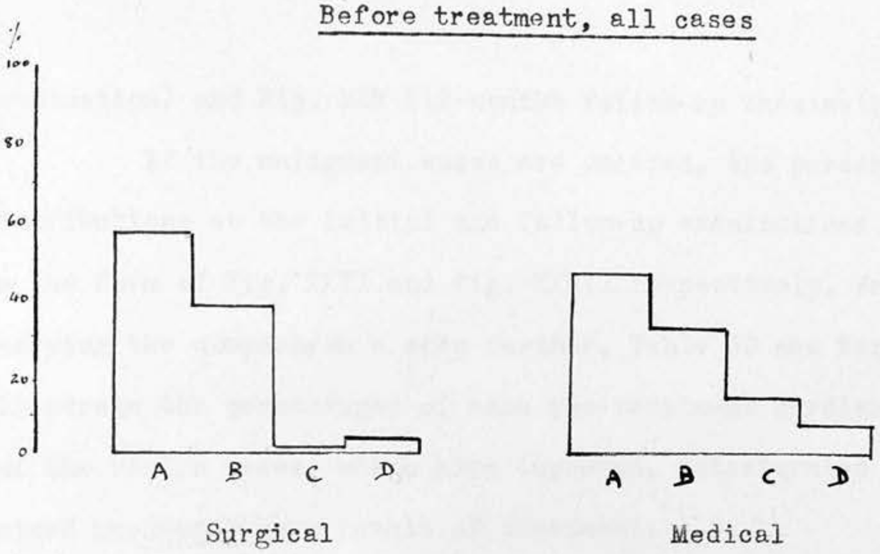
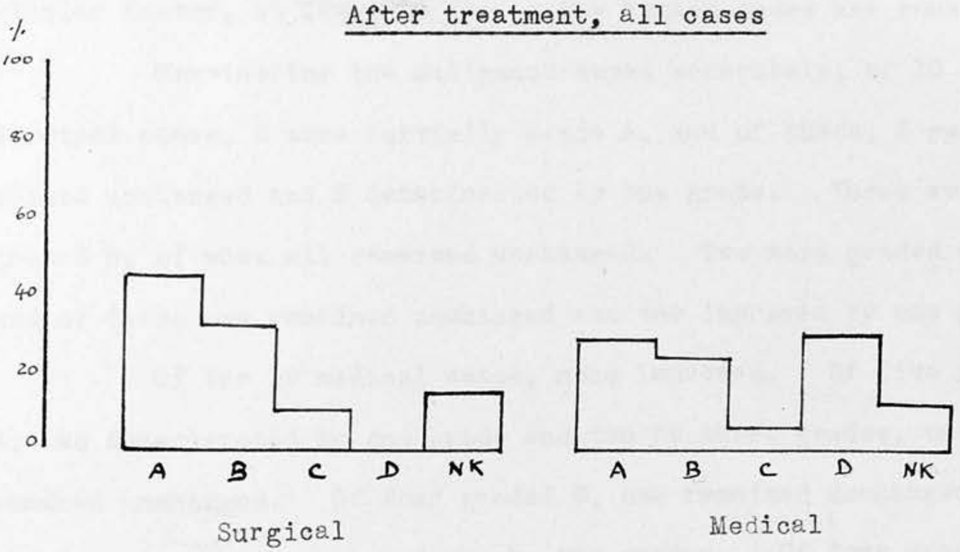


FIG. XXV

After treatment, all cases



Figs. XXIV and XXV: To show, for all cases, the percentage distribution among the 4 cardiac efficiency grades (A, B, C, D) before and after treatment.

examination) and Fig. XXV (12-months follow-up examination).

If the malignant cases are omitted, the percentage distributions at the initial and follow-up examinations appear in the form of Fig. XXVI and Fig. XXVII respectively, and, carrying the comparison a step farther, Table 30 and Fig. XXVIII illustrate the percentages of each pre-treatment cardiac grade (of the benign cases) which have improved, deteriorated or remained unchanged as a result of treatment.

From these results there is no evidence that one or other type of treatment is more beneficial as regards this particular factor, at least as far as the benign cases are concerned.

Considering the malignant cases separately, of 10 surgical cases, 5 were initially Grade A, and of these, 2 remained unchanged and 3 deteriorated by one grade. Three were graded B, of whom all remained unchanged. Two were graded C, and of these one remained unchanged and one improved by one grade.

Of the 19 medical cases, none improved. Of five graded A, two deteriorated by one grade and two by three grades, one remained unchanged. Of four graded B, one remained unchanged, two deteriorated by one and one by two grades. Of four graded C, two were unchanged, two deteriorated by one grade. Of six graded D all remained unchanged.

There is thus no material difference between surgical and medical treatment either in the benign or the malignant cases as regards the factor of cardiac efficiency. This is borne out by the statistical calculations on the matched groups which show a very slight difference in favour of surgery but not large enough to be significant.

5./

FIG. XXVI

Benign cases, Before treatment

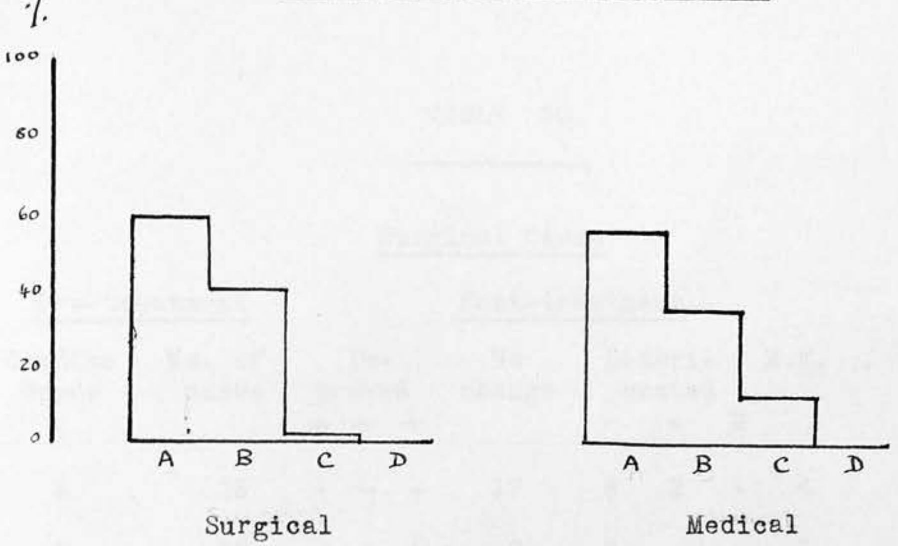
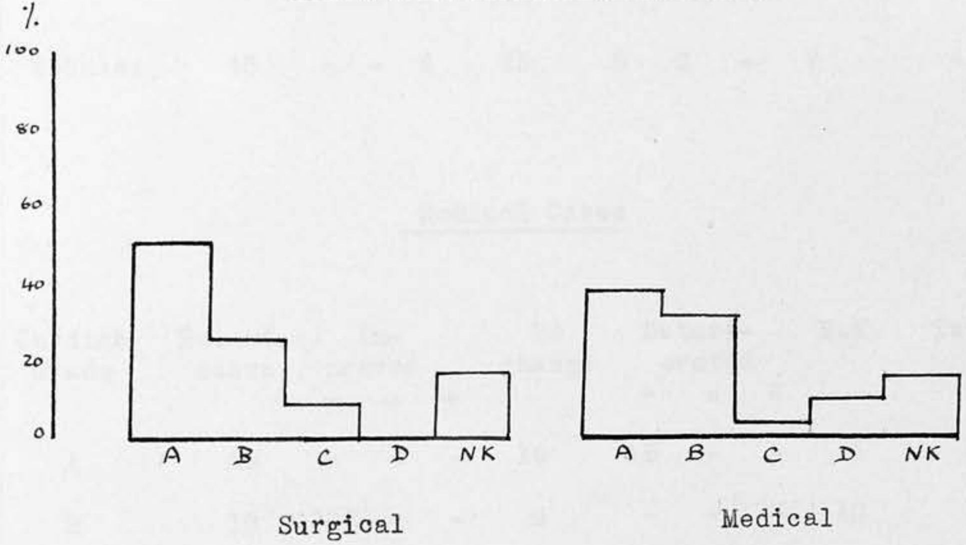


FIG. XXVII.

Benign Cases, After Treatment



Figs. XXVI and XXVII: To show, for the benign cases alone, the percentage distribution over the 4 cardiac efficiency grades, before and after treatment.

TABLE 30

Surgical Cases

Pre-treatment		Post-treatment								
Cardiac Grade	No. of cases	Improved			No change	Deteriorated			N.K.	Total
		+++	++	+		-	=	≡		
A	26	-	-	-	17	3	2	-	4	26
B	18	-	-	5	8	2	-	-	3	18
C	1	-	-	1	-	-	-	-	-	1
D	-	-	-	-	-	-	-	-	-	-
Totals:	45	-	-	6	25	5	2	-	7	45

Medical Cases

Cardiac Grade	No. of cases	Improved			No change	Deteriorated			N.K.	Total
		+++	++	+		-	=	≡		
A	29	-	-	-	19	5	-	-	5	29
B	19	-	-	-	9	-	-	-	10	19
C	7	-	-	4	1	-	-	-	2	7
D	-	-	-	-	-	-	-	-	-	-
Totals:	55	-	-	4	29	5	-	-	17	55

Table 29: To show the results of the two forms of treatment in each pre-treatment cardiac grade in degrees of improvement or deterioration.

N.K. means "not known"

FIG. XXVIII

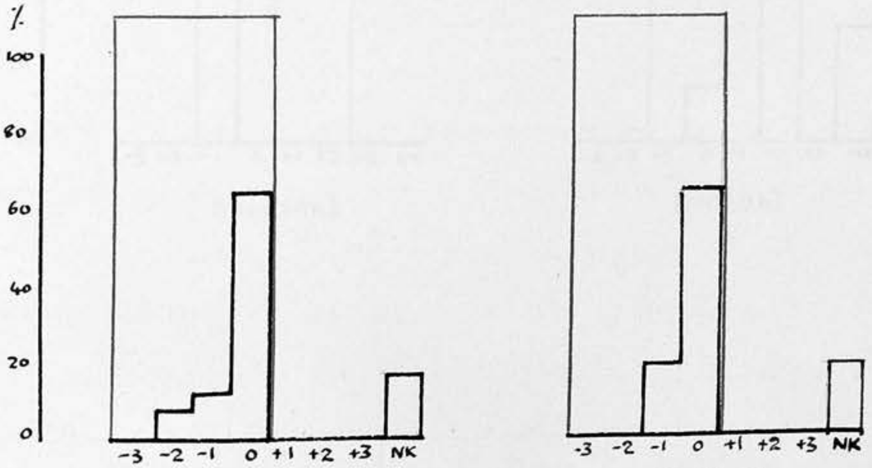
Fig.XXVIII: To show the percentages of each pre-treatment cardiac grade (A, B and C) which had improved, deteriorated or remained unchanged at the 12-months follow-up examination

Key to Diagram:

+ 1, +2, denote improvement by one or two grades respectively.
-1, -2, " deterioration " " " " " "
0 denotes no change.

The lines in red indicate maximum change in either direction through which a patient in this pre-treatment grade can change.

Pre-treatment Cardiac Grade A

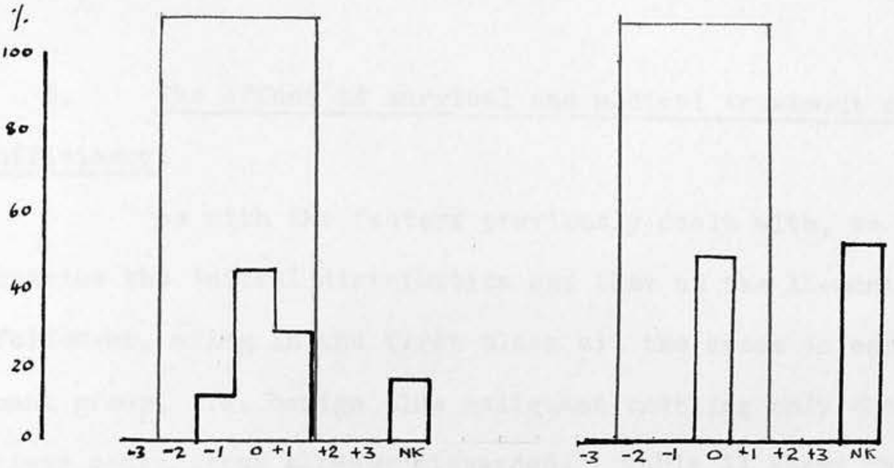


Surggical

Medical

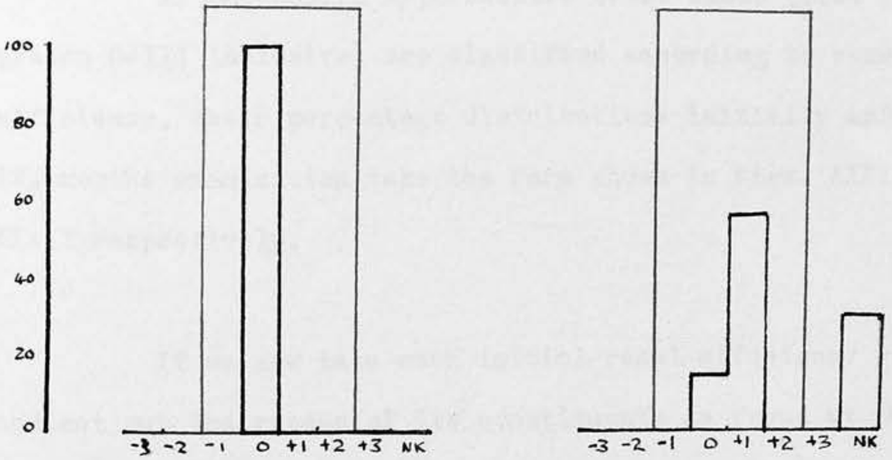
FIG. XXVIII (cont.)

Pre-treatment cardiac Grade B



Surgical Medical

Pre-treatment Cardiac Grade C



Surgical Medical

5. The effect of surgical and medical treatment on renal efficiency.

As with the factors previously dealt with, we shall examine the initial distribution and that at the 12-months follow-up, using in the first place all the cases in each treatment group, i.e. benign plus malignant, omitting only the third class comparisons already discarded. Table 31 shows the distribution in the various renal grades at the initial examination; Table 32 shows that at the 12-months follow-up examination, both correlated with retinal grades.

Fig. XXIX expresses the facts contained in Table 31 as a percentage distribution, and Fig. XXX does the same for Table 32.

If the benign hypertensive cases alone (i.e. retinal grades 0-III inclusive) are classified according to renal efficiency, their percentage distributions initially and at the 12.-months examination take the form shown in Figs. XXXI and XXXII respectively.

If we now take each initial renal efficiency grade and set out the grades of its constituents as found at the examination 12 months later we have results such as are seen in Table 33; further, when each surgical grade is compared with its fellow in the medical series with respect to the percentage of its constituent members who improved, deteriorated or remained unchanged at the end of the year, the results are found to be those set out in Fig. XXXIII.

From this diagram we can obtain the following

Information/

TABLE 31

Surgical Cases

Pre-treatment Retinal Grade	Males				Females				Total
	A	B	C	D	A	B	C	D	
0	1	2	-	-	6	1	-	-	10
I	3	2	-	-	6	7	-	-	18
II	5	3	-	-	5	1	-	-	14
III	-	1	1	-	-	1	-	-	3
IV	-	4	1	-	-	5	-	-	10
Totals:	9	12	2	-	17	15	-	-	55

Medical Cases

Pre-treatment Retinal Grade	Males				Females				Total
	A	B	C	D	A	B	C	D	
0	3	-	-	-	5	8	1	1	18
I	-	1	2	-	3	7	1	-	14
II	1	3	1	-	8	3	1	-	17
III	-	-	2	-	-	2	1	1	6
IV	-	1	1	12	-	-	-	5	19
Totals:	4	5	6	12	16	20	4	7	74

Table 31: To show the distribution of renal efficiency grades at the initial examination correlated with initial retinal grade, and using both benign and malignant cases.

TABLE 32

Surgical Cases

Initial Retinal Grade	Males A	B	C	D	NK	Females A	B	C	D	NK	Total
0	2	-	-	-	1	7	-	-	-	-	10
I	2	2	-	-	1	6	2	-	-	5	18
II	7	1	-	-	-	5	-	-	-	1	14
III	1	1	-	-	-	-	1	-	-	-	3
IV	2	1	-	2	1	1	3	1	-	-	10
Totals:	14	5	-	2	2	19	6	1	-	6	55

Medical Cases

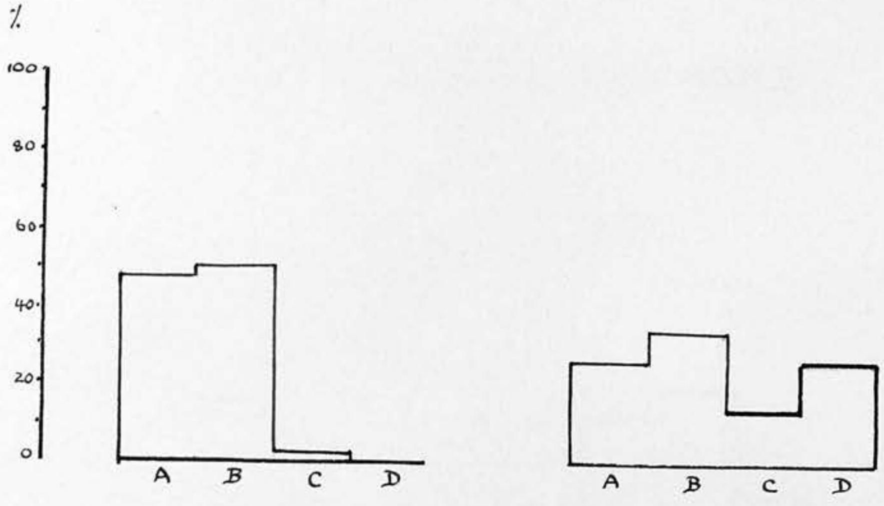
Initial Retinal Grade	Males A	B	C	D	NK	Females A	B	C	D	NK	Total
0	-	-	-	-	3	3	8	1	-	3	18
I	1	-	-	1	1	1	7	-	-	3	14
II	-	3	1	-	1	6	4	1	-	1	17
III	-	-	1	-	1	-	1	-	-	3	6
IV	-	1	1	12	-	-	-	-	5	-	19
Totals:	1	4	3	13	6	10	20	2	5	10	74

Table 32: To show the distribution of renal efficiency grades at the 12 month follow-up examination for both benigh and malignant cases, correlated with retinal grade.

(NK means "not known")

FIG. XXIX

Before treatment

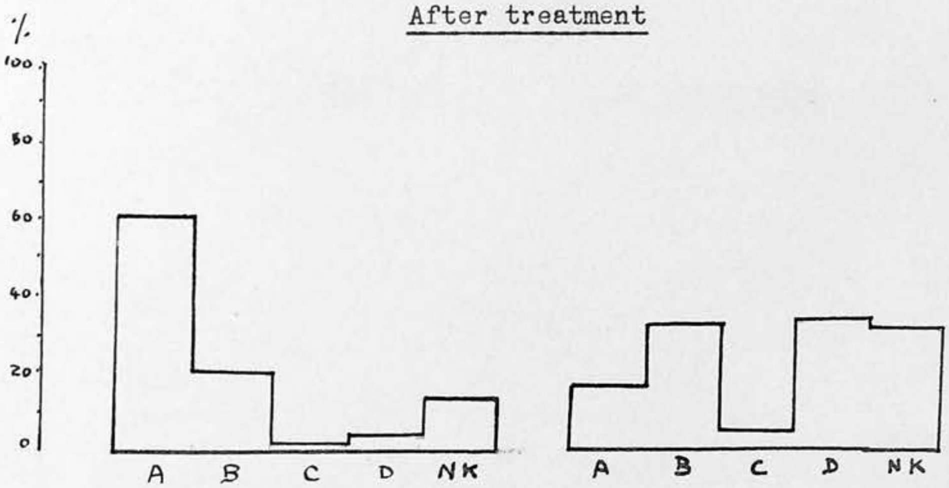


Surgical

Medical

FIG. XXX

After treatment



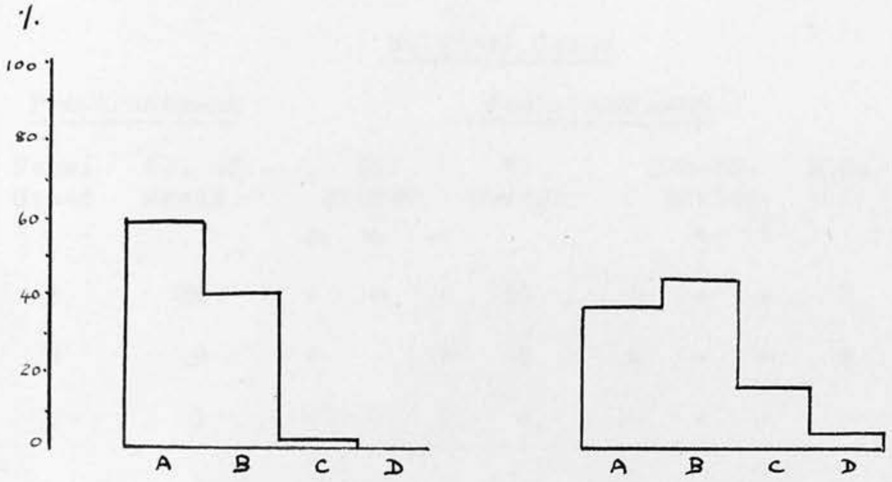
Surgical

Medical

Figs. XXIX and XXX: To show the distribution of renal efficiency before and after treatment. over the four grades, A, B, C, D. (N.K. = not known.)

FIG. XXXI

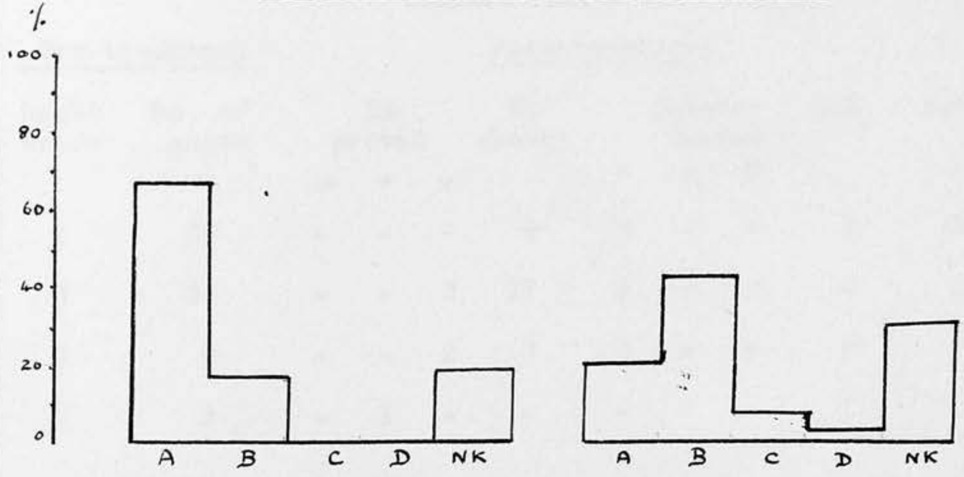
Before treatment: benign cases only



Surgical Medical

FIG. XXXII

After treatment: benign cases only



Surgical Medical

Figs. XXXI and XXXII: To show the distribution of renal efficiency grades for benign cases only, before and after treatment.

TABLE 33

Surgical Cases

Pre-treatment		Post-treatment								
Renal Grade	No. of cases	Improved			No change	Deteriorated			N.K.	Total
		+++	++	+		-	=	≡		
A	26	-	-	-	21	3	-	-	2	26
B	18	-	-	9	3	-	-	-	6	18
C	1	-	-	1	-	-	-	-	-	1
Total:	45	-	-	10	24	3	-	-	8	45

Medical Cases

Pre-treatment		Post-treatment								
Renal Grade	No. of cases	Improved			No change	Deteriorated			N.K.	Total
		+++	++	+		-	=	≡		
A	20	-	-	-	9	4	-	-	7	20
B	24	-	-	2	17	1	-	-	4	24
C	9	-	-	2	3	1	-	-	3	9
D	2	-	1	-	-	-	-	-	1	2
Total:	55	-	1	4	29	6	-	-	15	55

Table 33: To show, for each pre-treatment renal grade, the numbers of its constituent members at the 12 months follow-up examination who improved, deteriorated or remained unchanged.

FIG. XXXIII

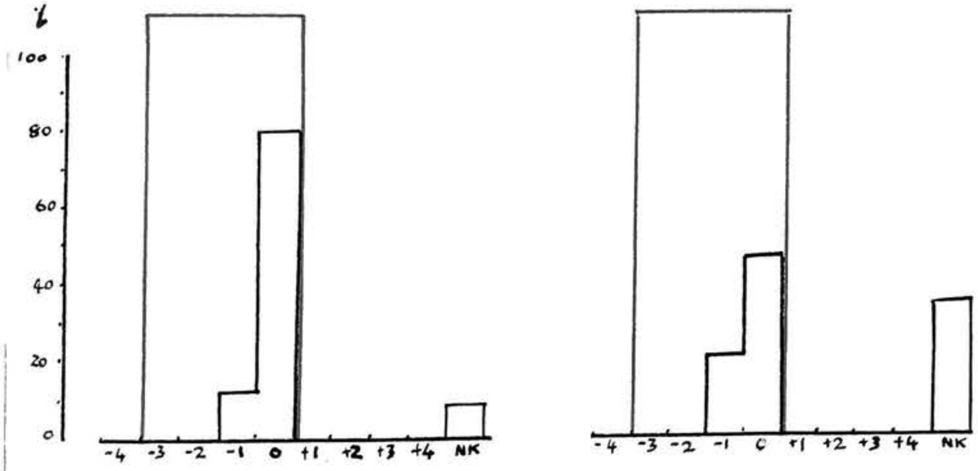
Fig. XXXIII: To show the percentages of each pre-treatment renal grade (A, B, and C: there were no D cases) which had improved, deteriorated and remained unchanged at the 12-month follow-up examination.

Key to Diagram:

+1, +2, denote improvement by one or two grades respectively
-1, -2, " deterioration " " " " " "
0 denotes no change

The lines in red indicate the maximum change in either direction through which a patient in this pre-treatment grade can change.

Pre-treatment Renal Grade A

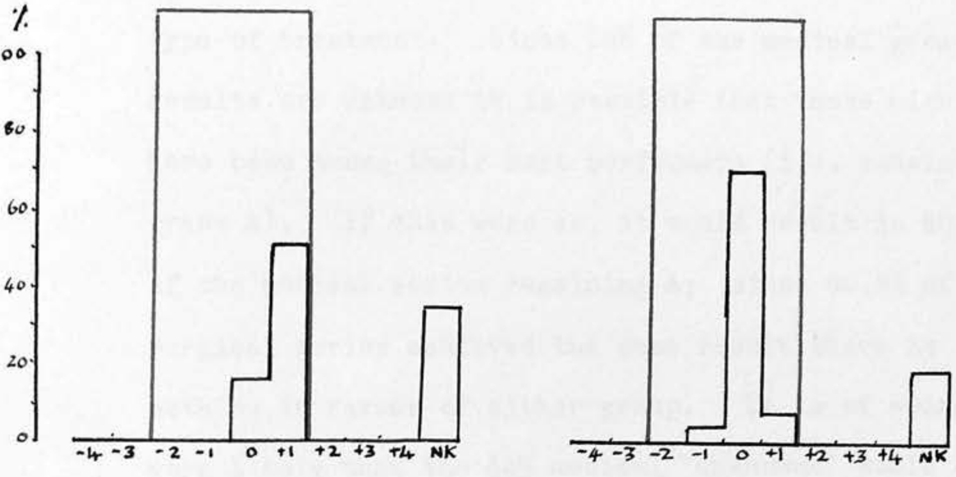


Surgical

Medical

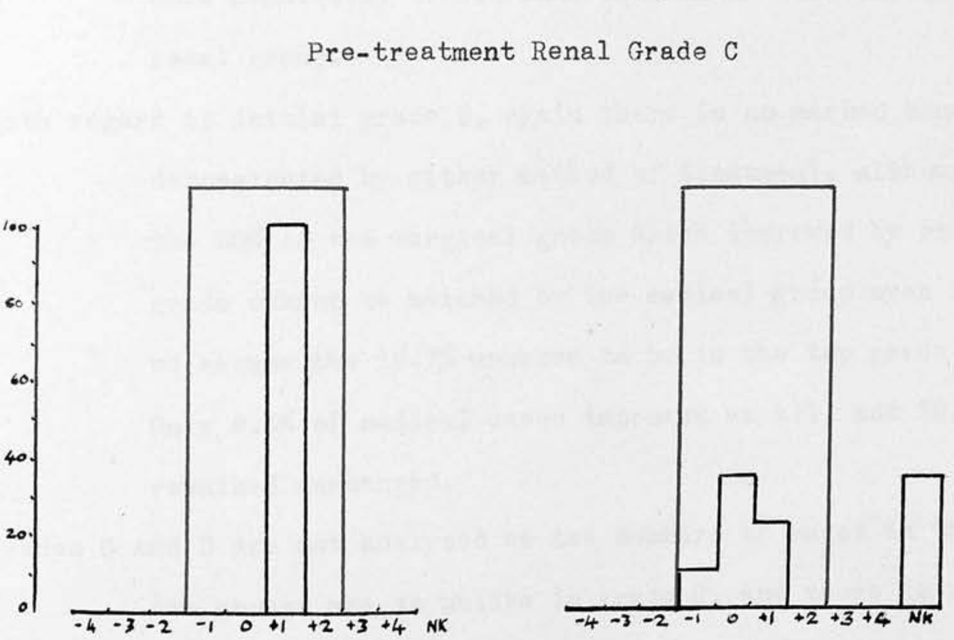
FIG. XXXIII (cont.)

Pre-treatment Renal Grade B



Surgical Medical

Pre-treatment Renal Grade C



Surgical Medical

information:

Initial renal grade A: There is no advantage here from either type of treatment. Since 35% of the medical group results are unknown it is possible that these might all have been among their best performers (i.e. remained grade A). If this were so, it would result in 80.0% of the medical series remaining A; since 80.8% of the surgical series achieved the same result there is nothing in favour of either group. It is of course more likely that the 35% medical "unknowns" would be distributed over one or two grades or even gravitate towards the lower type of performance, and thus the chances are in favour of surgical treatment having a more beneficial effect than medical in this initial renal grade.

With regard to initial grade B, again there is no marked benefit demonstrated by either method of treatment, although the 50% of the surgical group which improved by one grade cannot be matched by the medical group even if we assume the 16.7% unknown to be in the top grade. Only 8.3% of medical cases improved at all, and 70.8% remained unchanged.

Grades C and D are not analysed as the numbers of cases in the two groups are so unlike in grade C, and there is no grade D case in the surgical series.

In the benign group of cases therefore, if either method of treatment has shown up better it is the surgical, but to/

to a very slight extent.

Turning now to the malignant cases we find that of the 9 cases initially graded B, 3 have improved to A, 4 remained unchanged and 2 deteriorated, one to C and the other to D. The one case initially graded C deteriorated to D. Thus in the surgical series 30% have improved, 40% are unchanged and the remainder have deteriorated.

The medical malignant cases were mostly grade D at the outset, 17 out of 19 being so classed, one being C and one B. All these cases remained unchanged at the time of death (average 2.8 months after the initial examination).

Surgery therefore has more to offer the malignant hypertensive case where renal function is concerned than has medical treatment, but taking malignant and benign casea as a whole the balance is scarcely more in favour of one than of the other type of treatment.

The statistical work on the matched groups showed a slight difference in favour of surgical treatment, but as in the case of the cardiac efficiency factor, this difference was not statistically significant.

We now come to the second major part of the section dealing with the results of treatment.

B. Comparison of the Mortality Rates in the Surgical and Medical Groups.

The second part of the statistical analysis of results concerns the death incidence. Including all surgical cases and the first- and second-class medical comparisons, there were records of 128 patients of whom 36 died. It was soon obvious that the death rates in the benign hypertensives (matched groups 1-4 inclusive) and in the "malignant" cases (group 5 with its sub-divisions) were so widely different that these two types of case were best treated separately, as indeed they have been, for the most part, in the foregoing detailed comparison of results.

In the benign groups were 45 surgical cases with 5 deaths, and 55 medical cases with 7 deaths. On the crude figures there is no evidence of any difference, and this is confirmed by more detailed analysis. The patients were of disparate ages and had been under observation for periods varying from a few months to several years (5 years in the medical and $8\frac{1}{2}$ years in the surgical cases). The older the patient, and the longer the period under observation, the greater the risk of death.

For each patient there was calculated the chance of dying during the period of observation if he or she had the same death risk as prevailed for persons of like age and sex in the general population, as listed in the Life Table for Scotland for 1931. The period of risk for survivors was taken as the time since the first examination, and for deceased persons as the period from the first examination until death. The sum of the figures for all the patients in a group gives the number of "expected/

"expected deaths"; these data are shown in Tables 34A and 34B which deal with surgical and medical cases respectively.

It will be seen that there were five deaths in the surgical group against an expected death-rate of 1.12, and in the medical group seven deaths against an expectation of 1.33. This indicates that the death rates for persons with benign hypertension is about five times that prevailing in the population as a whole, and there is no evidence, on these small numbers of any difference between surgical and medical cases.

Among the <u>malignant</u> cases there were 10 surgical patients of whom 5 died, and 18 medical patients of whom 17 died. (There were originally 19 medical first and second class comparisons, but one died a few days after admission to hospital and is therefore not included in the mortality statistics.)

At first sight this looks like a marked recommendation of surgical treatment, but further enquiry shows that the two groups of cases are not strictly comparable. All the cases surgically treated were recommended for operation by the physicians and accepted by the surgeons. The medical cases however fall into three categories: <u>A</u>. Cases where there was no contraindication to surgical treatment. <u>B</u>. Cases recommended for operation by the physicians but refused by the surgeons,usually on account of poor or borderline renal function, but in any case contraindicated by failure of the individual to achieve the minimum standard in only <u>one</u> criterion. <u>C</u>. Cases for whom the physicians did not recommend operation, usually on account of advanced cardiac and renal failure.

It must be noted that two of the surgical cases,

TABLE 34A

Surgical Cases

Sex	Group	No. of cases	Deaths Expected	Deaths Observed
M.	1	3	0.0699	1
	2	5	0.2896	0
	3A	6	0.1891	0
	3B	2	0.0177	0
	4	2	0.0424	0
All male cases:		18	0.6087	1
F.	1A	3	0.0422	0
	1B	1	0.0077	0
	1C	3	0.0882	0
	2A	2	0.0166	0
	2B	4	0.0802	1
	2C	7	0.1566	2
	3A	3	0.0571	1
	3B	3	0.0458	0
	4	1	0.0178	0
All female Cases:		27	0.5122	4
Total:		45	1.1209	5

Table 34A: To show the relation of "expected" to "observed" deaths in the surgically treated group.

TABLE 34B

Medical Cases

Sex	Group	No. of cases	Deaths Expected	Deaths Observed
M.	1	3	0.0568	0
	2	3	0.0845	2
	3A	2	0.0416	0
	3B	3	0.0928	0
	4	2	0.0321	1
All male cases:		13	0.3078	3
F.	1A	4	0.0689	0
	1B	6	0.2262	0
	1C	5	0.1551	1
	2A	2	0.0473	0
	2B	4	0.0665	0
	2C	5	0.1165	0
	3A	5	0.0756	1
	3B	7	0.2253	0
	4	4	0.0387	2
All female cases:		42	1.0201	4
Totals:		55	1.3297	7

Table 34B: To show the relation of "expected" to "observed" deaths in the medically treated group.

although they in fact were operated on, should properly be graded B according to the above standards.

Details of the surgical and medical cases in these categories are set out in Table 35.

It will be seen that of the 8 surgical "A" cases, 4 died after an average interval of 15.4 months and 4 have lived for an average period of 26 months after being first treated. There were 5 medical "A" cases, all of whom died after an average interval of 5.2 months.

Of the 2 surgical "B" cases, one died at 5 months after the operation; the other is alive and has been observed for 14 months since her sympathectomy. Of 9 medical "B" cases, 8 died after an average interval of 1.8 months and one has survived for the short period of 3.5 months.

The 4 medical "C" cases died after an average interval of 1.3 months.

The only valid control for the main body of surgical cases is the "A" group of medical patients. As far as the comparison goes, in both A and B categories, the comparative death rate seems to favour surgical treatment, but the data is insufficient for a definite decision. The physicians in charge of the medical "A" cases are of the opinion, on clinical grounds, that these patients would have lived longer had they been operated on; unfortunately for them, they came under observation for the first time in the days when grade IV retinitis was considered one of the main contra-indications to sympathectomy.

For statistical purposes a much larger series of malignant hypertensive cases is requited. It will always be difficult/

TABLE 35

PROGNOSIS "A"

Surgical

Died				Survived			
Group	Sex	Age	Months lived	Group	Sex	Age	Months observed
5A	M	46	9	5A	M	44	18
5B	M	61	10	5A	M	47	50
5A	F	36	13.5	5A	F	45	22
5A	F	45	29	5A	F	45	14

4 cases Mean - 15.4 months 4 cases Mean - 26 months

Medical

Died				Survived			
Group	Sex	Age	Months lived	Group	Sex	Age	Months Observed
5A	M	40	1		NIL		
5A	M	44	2				
5B	M	60	6				
5A	F	57	12				
5A	F	31	5				

5 cases Mean - 5.2 months

TABLE 35
(cont.)

PROGNOSIS " B "

Surgical

Died				Survived			
Group	Sex	Age	Months lived	Group	Sex	Age	Months observed
5C	M	45	5	5B	F	44	14

Medical

Died				Survived			
Group	Sex	Age	Months lived	Group	Sex	Age	Months observed
5A	M	49	5	5C	M	56	35
5A	M	50	2				
5A	M	66	0.5				
5A	M	54	1				
5B	M	53	1				
5C	M	64	3				
5A	F	48	1				
5B	F	49	1				

8 cases Mean - 1.8 months

PROGNOSIS " C "

Surgical: No cases

Medical

Died			
Group	Sex	Age	Months lived
5A	M	51	0.3
5C	M	53	0.5
5C	M	48	3
5B	F	56	1.5

4 cases Mean - 1.3 months

difficult to collect a surgical group to compare with medical "B" cases, and yet this is the group about which more information is urgently needed. We do not know what the effect of surgical treatment will be on patients who are just over the borderline into renal failure; this type of malignant case occurs, in our experience, more commonly, and is more difficult to decide about, that the individual with early cardiac failure. We feel, in spite of the limited number of cases observed, that no patient who has been or is in cardiac failure should be treated surgically since in our experience such a patient does badly and derives no benefit from the treatment. But we are anxious that more cases in early renal failure should have the chance of surgery, especially since impaired renal function is often the sole factor which weighs against them from the surgeon's point of view. In our small series of malignant cases, renal function was found to be improved by sympathectomy.

Only by coming to an arrangement with the neurosurgeons, whereby they agree to operate on, say, every alternative malignant case who shows early renal impairment with slight nitrogen retention, can one hope to collect information regarding this problem. This plan would harm no patient; it might well benefit many, and would inevitably provide clinical information of a kind which is urgently needed at the present time.

The Mortality Rate in Obese Hypertensive Patients.

Before leaving the subject of the mortality rate in hypertension we must dispose of the possibility that obesity might have been a factor operating so as to increase the rate in our/

our series.

Body-weight was not one of the factors discussed in the section devoted to pre-treatment investigation, and it will now be mentioned briefly.

Hypertension and obesity frequently occur in one and the same individual - in fact this happens too often for the occurence to be due purely to chance. It has been noted that the blood-pressure of obese persons is on the average higher than that of normal persons but the nature of the connection between hypertension and obesity is not clear.

Since obesity per se, as shown by life insurance statistics, gives rise to increased mortality, it is natural to suppose that it would have an adverse effect on the mortality of hypertensives (36).

In our small series of benign cases of hypertension the incidence of obesity in relation to age is shown in Table 36.

Of 5 deaths in the surgical series none was obese; 2 were average and 3 underweight.

Of the 7 cases who died in the medical group only one was obese; one was average and 3 underweight.

Before we go on to discuss this matter in relation to the malignant cases, it is of interest to add that, besides having no bearing on the death-rate, body-weight has apparently little or no correlation with the patient's post-treatment progress as regards symptom-grade and diastolic pressure, at least as far as the benign cases of our series are concerned.

Correlation "grids" are shown for these factors (for both/

TABLE 36

Surgical Cases

Age group	Males						Females					
	Alive			Dead			Alive			Dead		
	O.	Av.	U.	O.	Av.	U.	O.	Av.	U.	O.	Av.	U.
19-29	-	2	-	-	-	-	-	-	3	-	-	-
30-39	-	2	-	-	-	-	6	3	1	-	-	2
40-49	4	2	1	-	-	1	3	2	2	-	1	1
50-59	-	4	2	-	-	-	1	1	1	-	-	-
60-69	-	-	-	-	-	-	-	-	-	-	-	-
Total:	4	10	3	-	-	1	10	6	7	-	1	3

Medical Cases

Age group	Males						Females					
	Alive			Dead			Alive			Dead		
	O.	Av.	U.	O.	Av.	U.	O.	Av.	U.	O.	Av.	U.
19-29	-	-	-	-	-	-	1	-	-	-	-	-
30-39	-	1	1	-	-	-	4	-	2	-	-	-
40-49	3	1	-	-	-	2	7	4	4	1	1	1
50-59	2	1	-	-	-	1	6	7	2	-	-	1
60-69	-	1	-	-	-	-	1	-	-	-	-	-
Total:	5	4	1	-	-	3	19	11	8	1	1	2

Table 36: To show the incidence of the obese (O), the average (Av) and the underweight (U) individual in the surgical and medical groups, and the relation of body weight to death rate, in cases of benign hypertension.

both surgical and medical groups) in Fig. XXXIV.

In the surgical group, if anything, the thinner patients tend to have the higher blood-pressures at the 12-months follow-up; there is no correlation between initial weight and post-operative symptoms.

In the medical group, there is no correlation between body-weight and either post-treatment diastolic pressure or post-treatment symptoms.

Turning now to the malignant cases, we find that the higher mortality is quite definitely amongst underweight individuals; the malignant hypertensive symptom-complex has rapid loss of weight as one of its most characteristic features.

Of the 5 surgical malignant deaths, two were average and one stout. Of the 18 medical deaths, 13 were underweight individuals, the remainder average.

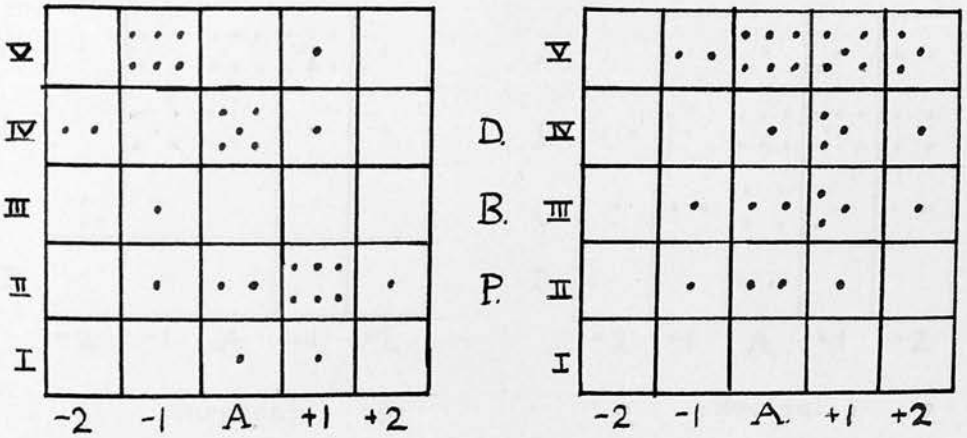
In this series, therefore, obesity seems to have no aggravating effect on the mortality rate; this finding agrees with that of Bechgaard (8) who had 311 cases of obesity.in his follow-up series of 1000 hypertensives, and who found that, contrary to expectation, the mortality rate in those 311 individuals was lower than that for the rest of the series.

Our numbers are much too small to warrant definite conclusions; indeed Bechgaard considers his series of 1000 not sufficiently large to exclude the possibility that the difference found is a matter of chance. In his cases, however, the finding that in all age-groups the trend is the same tends to suggest that chance has little to do with the results observed.

Before/

FIG. XXXIV (A)

Fig. XXXIV:(A)To show the correlation of body-weight at initial examination with basic diastolic pressure grade (I to V as in previous figures) at the 12-months follow-up examination.



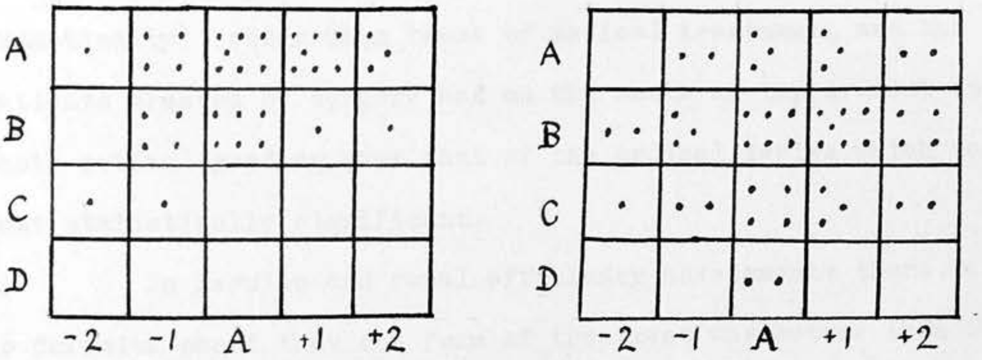
Surgical Medical

Key: Vertically: D.B.P. grades I to V

Horizontally: Grades of body weight:
A = average (up to 1 stone over or under correct weight)
+1 = more than 1 stone over weight
+2 = more than 2 stone over weight
-1 = more than 1 stone under weight
-2 = more than 2 stone under weight.

FIG. XXXIV (B)

Fig. XXXIV (B): To show the correlation between body-weight at the initial examination and symptom-grade (A, B, C, D) at the 12-months follow-up examination



Surgical Medical

Key: Vertically: symptom-grades A, B, C, D

Horizontally: body-weight grades as in XXXIV (A)

Before leaving this section of our report, in which an attempt has been made to evaluate the respective achievements of surgical and medical treatment by discussing in detail the factors of subjective symptoms, retinal grade, waking diastolic pressure, cardiac and renal efficiency, and finally the important subject of mortality rate, it will be advisable to summarise briefly our findings to date.

As far as symptomatic relief was concerned, and the ability of the patient to resume work, it was found that surgical treatment was by far the method of choice. Its achievements in reducing diastolic blood pressure were significantly (though not dramatically) better than those of medical treatment, and the patients treated by surgery had an the whole an improvement in their retinal grading over that of the medical series which was just statistically significant.

In cardiac and renal efficiency assessments there was no definite proof that one form of treatment was better than the other, and in the benign cases, the mortality rates in the surgical and medical groups were not materially different.

It should be emphasised once again that it is in the field of malignant hypertension that surgery has had its greatest triumphs. There is no doubt at all that it can prolong life and relieve the severest symptoms in this condition to a hitherto unsuspected degree, and, as we have already stated, the future should hold further therapeutic possibilities as still more severe cases are accepted for surgical treatment.

FURTHER EFFECTS OF TREATMENT

We come now to a section of our report dealing with factors which have not, owing to small numbers, been subjected to detailed statistical analysis as have those previously described, but a study of which, nevertheless, reveals much that is of interest. We shall deal now with (a) the electrocardiogram; (b) heart-size estimation; (c) the various blood pressure tests- sodium amytal, cold pressor and postural tests, with reference in each case to comparative results before and after treatment.

1. The Electrocardiogram

In the present investigation 38 of the benign surgical cases and 73 of the benign medical cases had a preliminary electrocardiogram carried out during their initial investigation.

The distribution of the initial E.C.G. grades A, B, C and D (the method of grading was described in an earlier section on "material of the investigation" p.19) is shown in Table 37, and their percentage distribution in Fig. XXXV.

Of these cases initially tested, only 22 surgical and 29 medical patients had the investigation repeated 12 months later. These individuals alone are used, therefore, in compiling Table 38 which shows, for each pre-treatment E.C.G. grade, the changes which have occurred during the 12 months.

Fig. XXXVI converts these facts into the percentages of each pre-treatment grade which have improved, deteriorated or remained in statu quo, and compares each surgical grade with its medical/

TABLE 37

Surgical Cases

Initial Retinal Grade	Males				Females				Total
	A	B	C	D	A	B	C	D	
0	-	-	1	-	3	4	-	-	8
I	1	1	1	-	1	7	4	-	15
II	2	2	4	-	-	4	-	-	12
III	-	2	-	-	-	1	-	-	3
Total:	3	5	6	-	4	16	4	-	38

Medical Cases

Initial Retinal Grade	Males				Females				Total
	A	B	C	D	A	B	C	D	
0	2	1	-	-	6	4	4	1	18
I	3	-	-	-	3	7	-	-	13
II	-	2	2	4	2	5	3	-	19
III	-	2	-	1	-	2	-	2	7
Totals:	5	5	2	5	11	18	7	4	57

Table 37: To show the distribution of initial E.C.G. grades for benign cases only.

FIG. XXXV

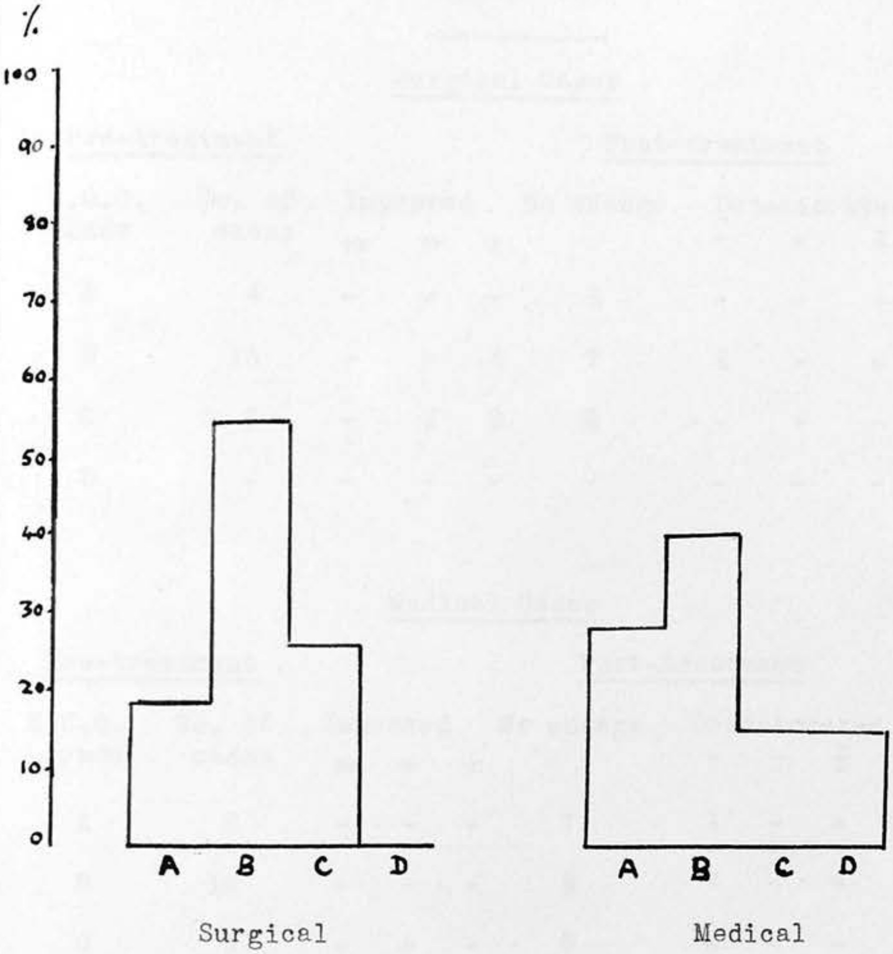


Fig. XXXV: To show the initial distribution of benign cases over the four electrocardiogram grades A, B, C, D.

TABLE 38

Surgical Cases

Pre-treatment		Post-treatment							
E.C.G. GRade	No. of cases	Improved			No change	Deteriorated			Total
		+++	++	+		−	=	≡	
A	4	-	-	-	4	-	-	-	4
B	13	-	-	4	7	2	-	-	13
C	5	-	2	2	1	-	-	-	5
D	-	-	-	-	-	-	-	-	-

Medical Cases

Pre-treatment		Pøst-treatment							
E.C.G. grade	No. of cases	Improved			No change	Deteriorated			Total
		+++	++	+		−	=	≡	
A	8	-	-	-	7	1	-	-	8
B	16	-	-	-	9	7	-	-	16
C	3	-	-	-	3	-	-	-	3
D	2	-	-	-	2	-	-	-	2

Table 38: To show, for each pre-treatment E.C.G. grade, the changes which have occurred at the time of the 12.month follow-up, i.e. actual numbers who have improved, deteriorated or remained unchanged.

FIG. XXXVI

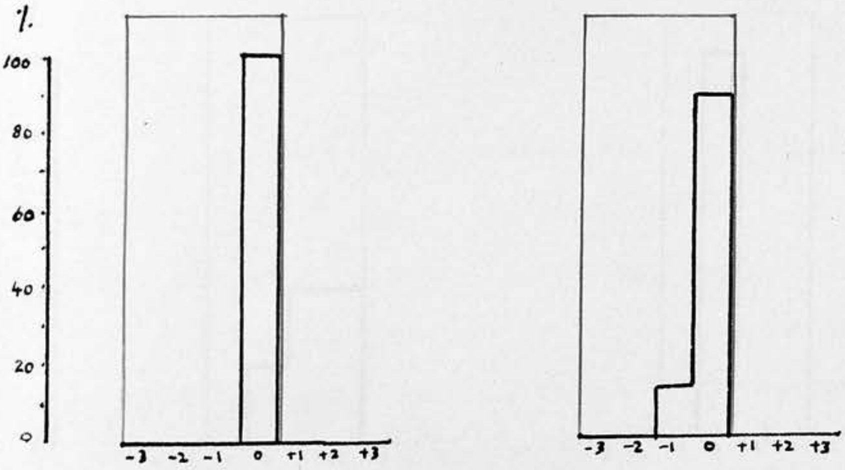
Fig. XXXVI: To show the percentage of each pre-treatment electrocardiogram grade which had improved, deteriorated or remained unchanged at the 12-months follow-up examination

Key to diagram:

+1, +2 denote improvement by one or two grades respectively
-1, -2 " deterioration " " " " " "
0 denotes no change

The lines in red indicate the maximum change in either direction through which a patient in this pre-treatment grade can change.

Pre-treatment E.C.G. Grade A

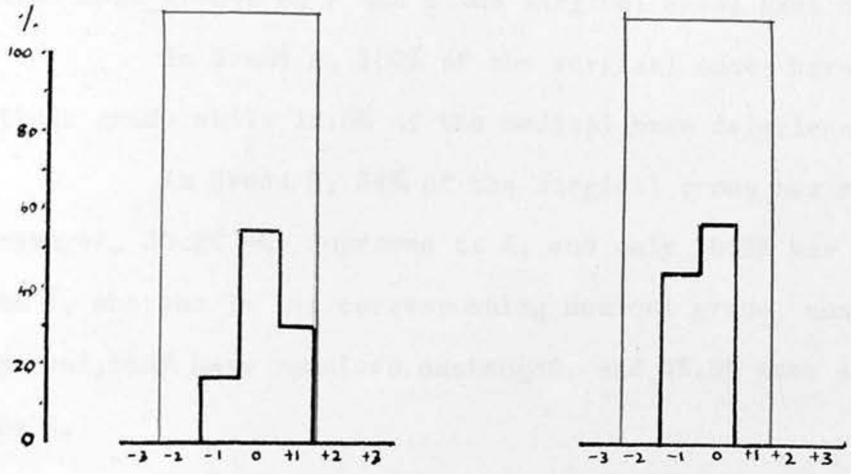


Surgical

Medical

FIG. XXXVI(Cont)

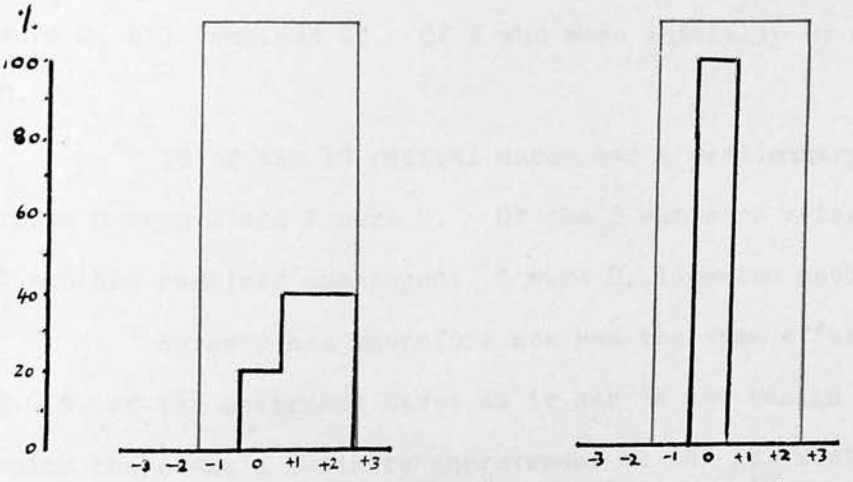
Pre-treatment E.C.G. Grade B



Surgical

Medical

Pre-treatment E.C.G. Grade C



Surgical

Medical

medical counterpart.

From Fig. XXXVI it is clear that in all three pre-treatment grades A, B and C the surgical cases have done better.

In Grade A, 100% of the surgical cases have maintained their grade while 12.5% of the medical have deteriorated into B.

In Grade B, 54% of the surgical group has remained unchanged, 30.8% has improved to A, and only 15.2% has deteriorated to C, whereas in the corresponding medical grade, none have improved, 56.2% have remained unchanged, and 43.8% have deteriorated to B.

In Grade C, 80% of the surgicals have improved (40% by 2 grades and 40% by one); the medical cases have all remained unchanged.

The foregoing figures refer, as we have stated, only to benign cases. In the surgical malignant group 9 out of the 10 patients were tested. Of two of those who were, initially grade B, one remained B, one dropped to C. Of 4 who initially were C, all remained C. Of 3 who were initially D, all remained D.

16 of the 19 medical cases had a preliminary test: of these 9 were C and 7 were D. Of the 5 who were retested, 3 were C and had remained unchanged: 2 were D, likewise unchanged.

Surgery has therefore not had the same effect on the E.C.G. of the malignant cases as it has in the benign group, in which there was a definite improvement at the 12.-months follow-up. It is of interest to compare the result obtained by Camabal et al. (14) writing on the electrocardiogram in hypertension. We reproduce the figures given in his paper in

Table 39/

Table 39 .

Our small series agrees on the whole with these figures: surgery offers the possibility of greater E.C.G. improvement than medical treatment does, and most writers agree that surgery prevents deterioration.

Now follow a few details regarding the <u>pre- and post-operative electrocardiograms</u> of the surgical cases.

The following points were specially noted in the standard leads:

1. The axis deviation (direction and amplitude)
2. The character of the ST segment in standard lead I.
3. The character of the T wave in standard lead I.

1. <u>Axis deviation</u>

In every case the axis deviation index () was calculated using the formula $(R_1 + S_3) - (R_3 + S_1)$ and the results are as shown on Table 40. Only 5.4% of the cases had an abnormal left axis (over 30) before operation; after operation this feature was shown in the E.C.G. of 8% of the cases.

Otherwise there was little difference as a result of operation.

2. <u>ST segment in lead I</u>

Depression or elevation was measured in millimetres and the results, pre- and post-operative, are as seen in Table 41. Here again there is little difference as a result of operation.

3./

TABLE 39

	"Surgical" Cases	%	"Medical" Cases	%
Improved	50	57.5	5	10
No change	20	29.8	20	40
Worse	11	12.7	25	50
	87	100.0	50	100

E.C.G. Findings of Canabal et al. (p. 53).

TABLE 40

Axis Deviation Index (groups)

	-20 to -11	-10 to 0	0 to +10	+11 to + 20	+21 to + 30	Over + 30	Cases Total
Pre-op.	-	5	7	12	12	2	38
Post-op.	1	3	11	13	6	4	38

Table 40: To show distribution of axis deviation index measurements before and after sympathectomy.

TABLE 41

Depression (-) or elevation (+) in millimetres of ST segment I.

		-2	-1	-0.5	0	+0.5	+1	+2	Total
Pre-op.	No.	-	5	1	31	1	-	-	38
Post-op.	No.	1	5	-	31	-	1	-	38

Table 41: To show distribution of ST segment abnormalities before and after sympathectomy.

TABLE 42

T wave depression (-) or elevation (+) in millimetres

		-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	Total
Pre-op.	No.	1	1	1	1	6	3	5	11	7	1	1	38
Post-op.	No.	1	1	1	1	4	2	11	6	9	2	0	38

Note: 35% of cases had an abnormal T (flat or inverted) before operation. 27% of cases had an abnormal T (flat or inverted) after operation.

Table 42: To show distribution of T wave measurements before and after sympathectomy.

3. T wave in lead I

The height and/or depth of the T wave was measured for each case before and after operation, and the result recorded in millimetres as shown in Table 42.

35% of cases had an abnormal T (flat or inverted) before operation; 27% of cases had an abnormal T (flat or inverted) after operation. There is thus a slight improvement in this respect.

It is to be noted that unipolar praecordial chest leads taken from a spot overlying the left ventricle furnish the most valuable information regarding the presence or absence of left ventricular hypertrophy. It is more difficult however to compare chest leads taken at different times than to compare limb leads, owing to the difficulty of being certain that the chest electrode was on precisely the same spot on both occasions.

In this investigation we have been exceptionally fortunate in having a highly skilled and reliable technician who had been responsible for taking almost all the records, hence this difficulty is largely imaginary.

In some cases however another hindrance to accurate comparison has cropped up: when most of our cases had their initial E.C.G., the precordial leads were of the type C_2F and CVF; more recently they have been replaced by the unipolar chest leads V_1 to V_6.

In only a very few cases, however, have we no accurate comparison of chest leads pre-operatively and post-operatively, at the 12-months interval.

Further/

Further references to the electrocardiogram in hypertension before and after sympathectomy are made by White et al. (67) who found, as a result of operation, an improvement in 57% of cases, deterioration in 13% and no change in 30%. In Hammarstrom's (30) series the corresponding percentages are 58%, 4% and 38% respectively.

In our small series of surgical cases, taking the initial grades separately, the figures are as follows:

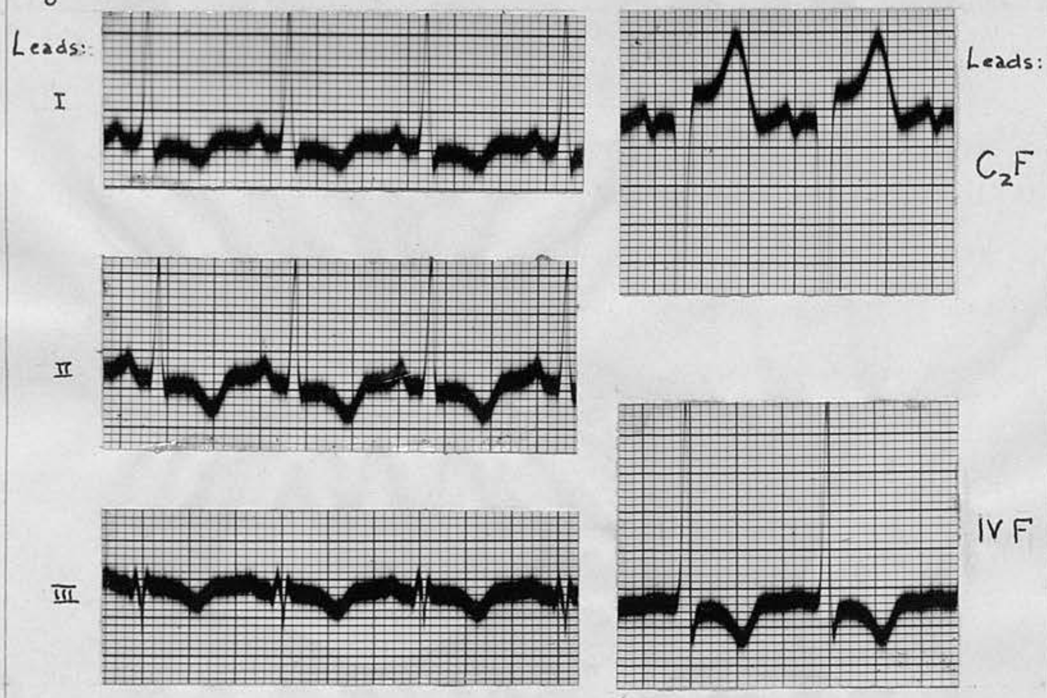
	Improved	No change	Deteriorated
Initial Grade A	-	100%	-
" " B	30.8%	54%	15.2%
" " C	80.0%	20%	-

Details now follow of some of those surgical cases which showed an improvement in the pattern of the E.C.G. during the first 12 months after treatment, illustrated by sections taken from the electrocardiograms.

Electrocardiographic improvements were of various types and degrees, e.g. T in lead I or II previously flat or inverted, now upright: disappearance of ST segment depression, etc. It is to be noted that in none of those surgical cases who had a grossly abnormal initial E.C.G. (grade D) was there any improvement after operation. These were 3 such cases in the series, all malignant hypertensives, and an example of this is shown by our first case.

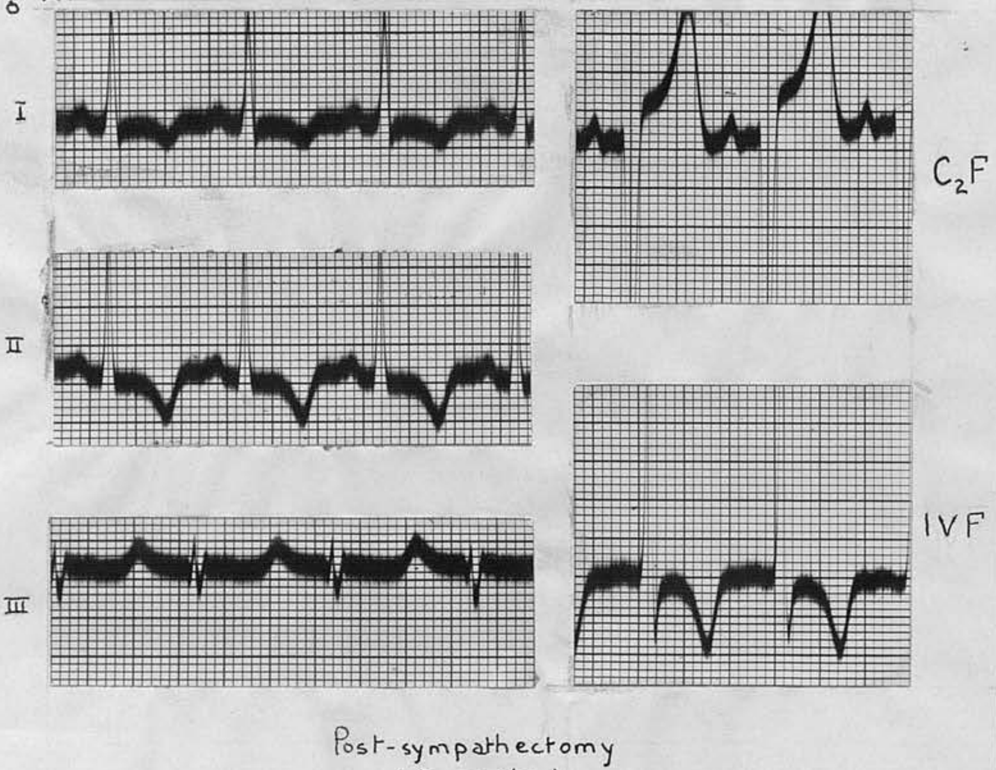
CASE 1. MRS M.S. aet. 44

Fig 1.



Pre-sympathectomy.

Fig 2.



Post-sympathectomy
(3 months)

Case 1. Mrs. M.S. aet. 44

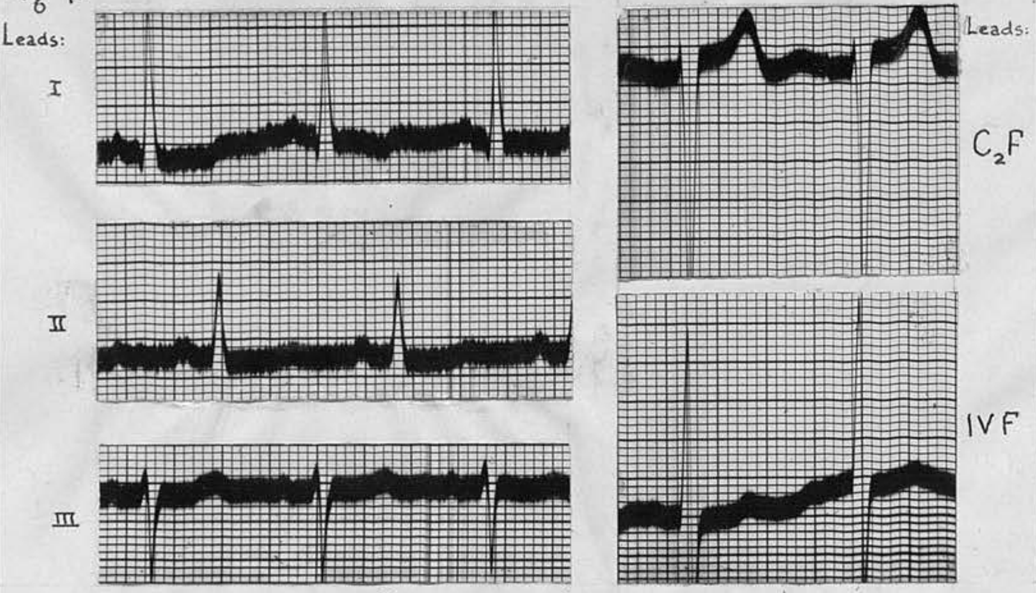
A case of malignant hypertension with a history of only four weeks duration; her only initial complaint was a headache which culminated in a cerebral haemorrhage causing left-sided hemiplegia.

She was of average physique, did well after operation and has been followed for a year. Her pre-operative diastolic pressure was 136 mm Hg.; now it is 156 mm Hg. There was initially very little cardiac enlargement; her retinae are now Grade III. She has no symptoms except for being handicapped by the hemiplegia, and can move about the house independently. Her renal function is normal.

Her electrocardiograms, both pre- and post-operative are of interest chiefly in that they show the typical pattern of marked left ventricular hypertrophy in leads I and II and the apical chest (IVF) lead, with large R, small S (in lead I) or larger S (as in the apical lead) ST depression and steeply inverted T.

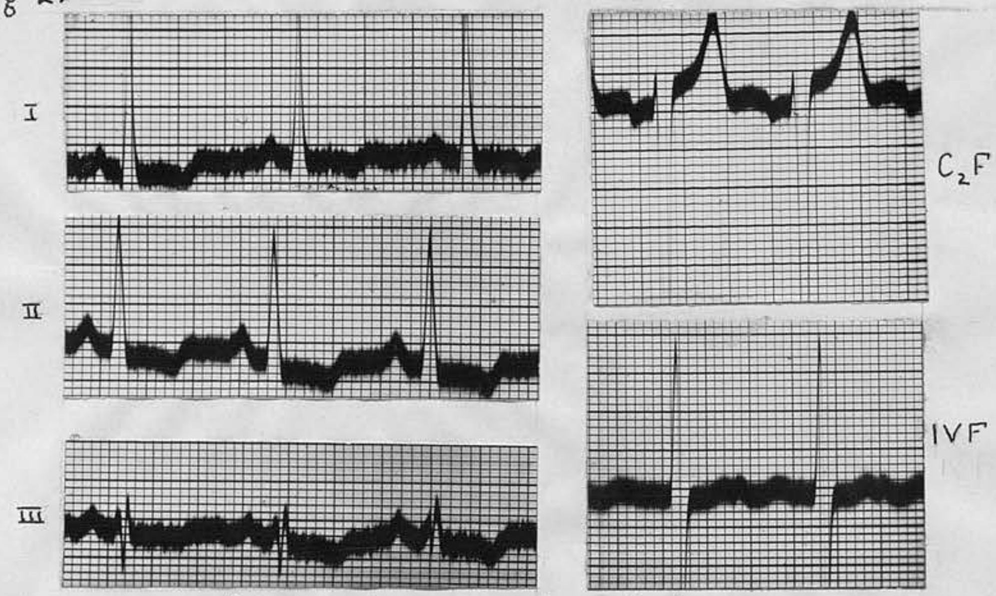
CASE 2. MRS M.F. aet. 33.

Fig 1.



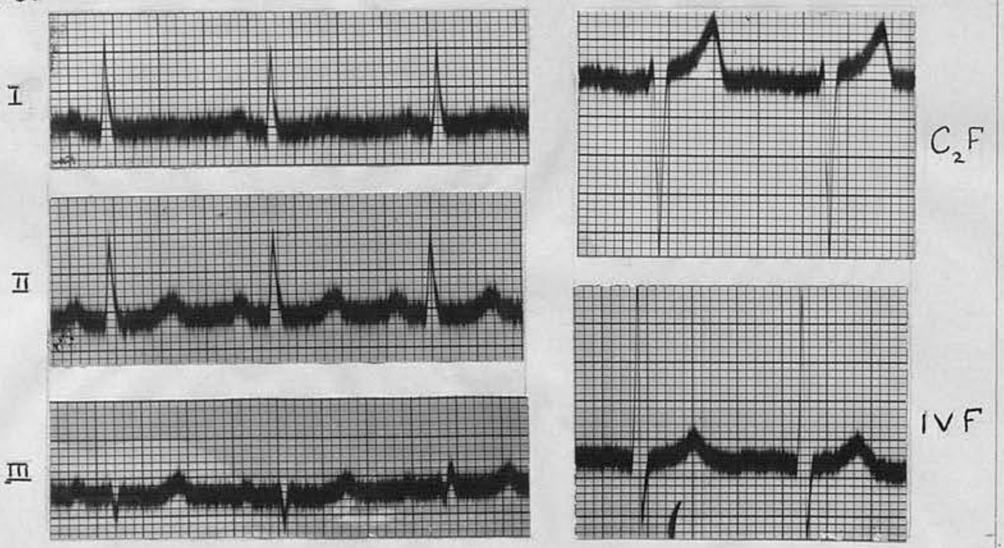
Pre-sympathectomy

Fig 2.



Pre-sympathectomy : 1 month later

Fig 3.



4 years post-sympathectomy

The next case illustrates reversal of the T wave to the normal pattern.

Case 2. Mrs. M.F. aet. 33

This patient's main initial complaint was of headache. She did very well after operation, but had a transient cerebrovascular accident 3½ years afterwards which cleared up in a few weeks.

She was of average physique. Her pre-operative diastolic pressure was 134 mm Hg.; a year later it was 120. There has never been any cardiac enlargement, and cardiac and renal efficiency are both normal. Her retinal grade deteriorated from I to II at the 4-year follow-up; it was not examined 12-months after operation.

Regarding her E.C.G.: During the month which elapsed between the first two records, both pre-operative, there is evidence of some deterioration: T in lead I is more deeply inverted; T in lead II from being low upright becomes inverted, and T in lead IV.F from being low upright becomes diphasic. The ST segment in lead II of the later pre-operative record is depressed, and lead II as a whole shows a typical pattern of left ventricular hypertrophy.

The third record shown here was taken four years after sympathectomy (one at the 12-month interval not being available) and it is clear that several changes for the better have taken place:

(a) T in lead I from being inverted is now flat

(b)/

(b) T in lead II is now upright.

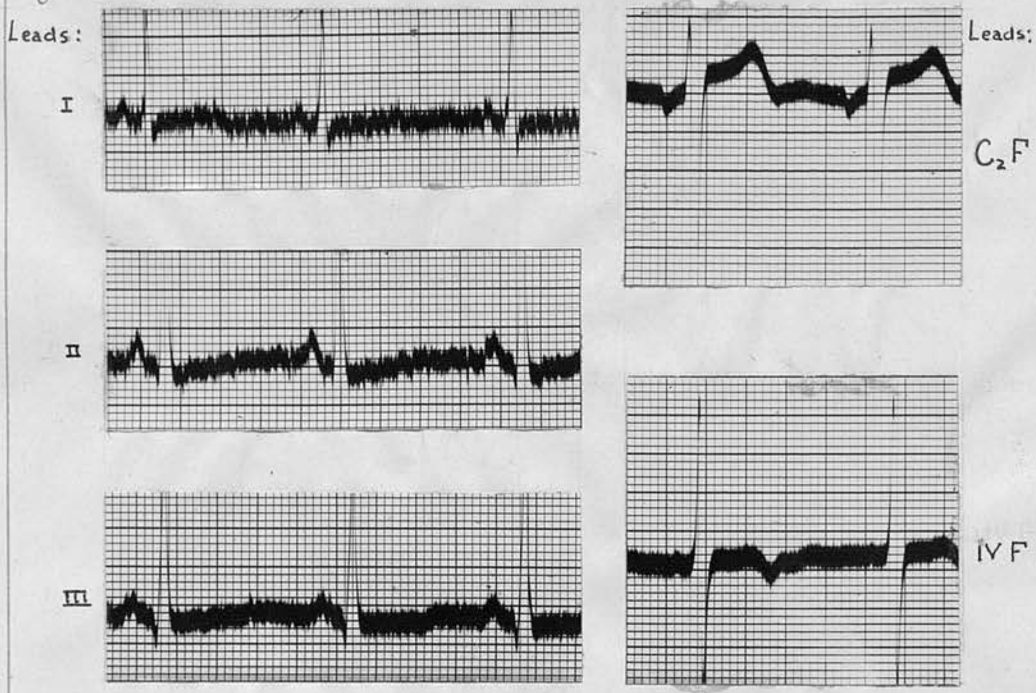
(c) T in IVF is now upright.

(d) The left ventricular hypertrophy pattern in lead II has disappeared and the ST segment is now normal.

(c) The left axis deviation index (although this is of less importance and may vary with the position of the heart) has been reduced from between 21 and 26 to 15.

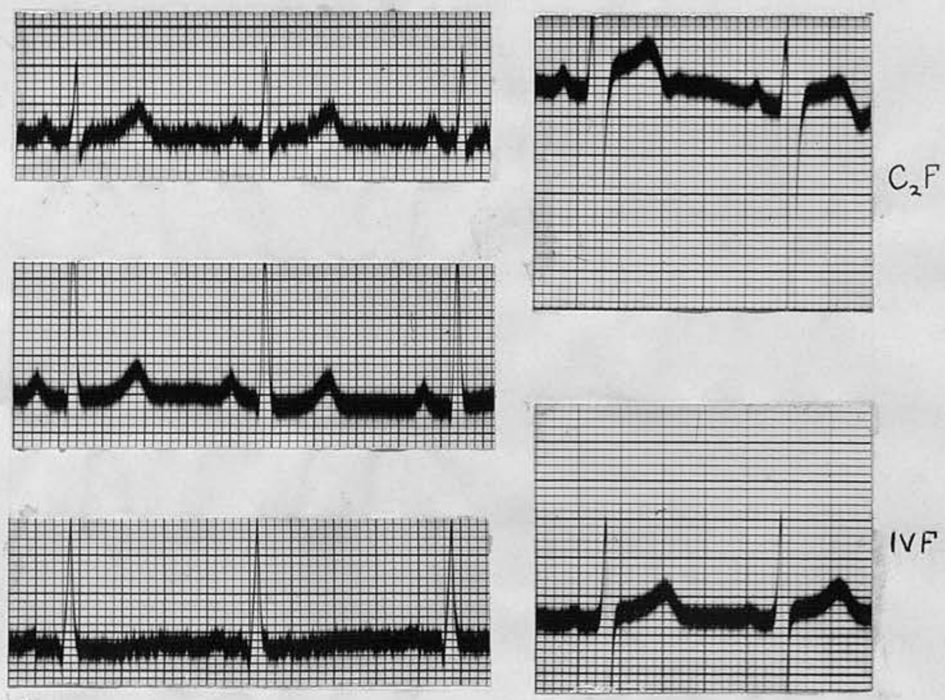
CASE 3. Miss J.B. aet 29.

Fig 1.



Pre-sympathectomy

Fig 2.



2 years post-sympathectomy

Case 3. Miss J.B. aet. 29

This patient had severe headaches prior to operation. Her basic diastolic pressure was 102 mm Hg. her retinal grade I, and cardiac and renal efficiency normal. She tended to be underweight.

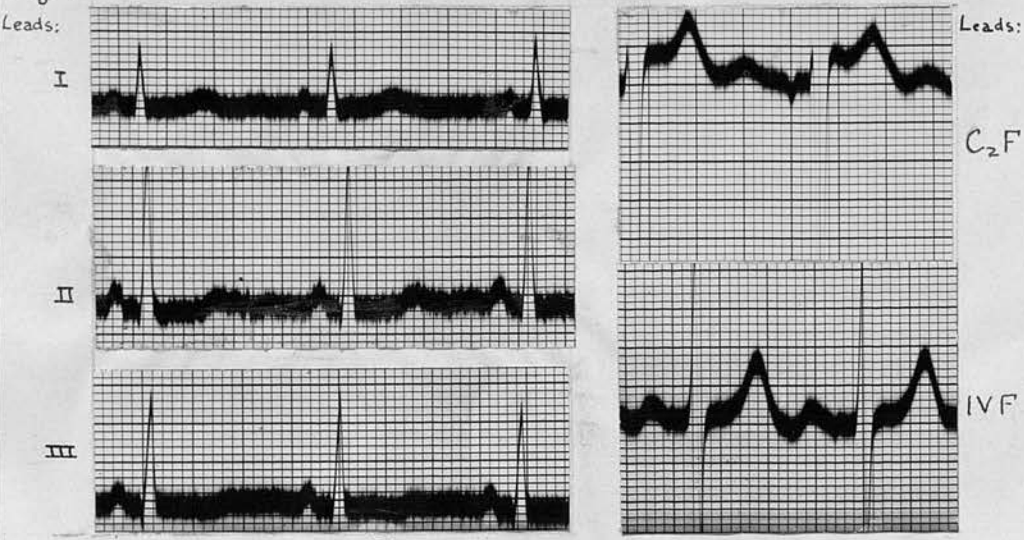
She has been followed now for 2½ years since her sympathectomy, and is symptom-free, basic diastolic pressure 120 mm Hg., retinal grade I (although they had improved to normal and remained so for 15 months after operation). Cardiac and renal efficiency are normal.

Her E.C.G. at the preliminary examination shows a flattened T in leads I and II, and a shapply inverted T in lead IVF.

2 years after operation the pattern shows a striking return to normality: T in leads I, II and IVF being upright.

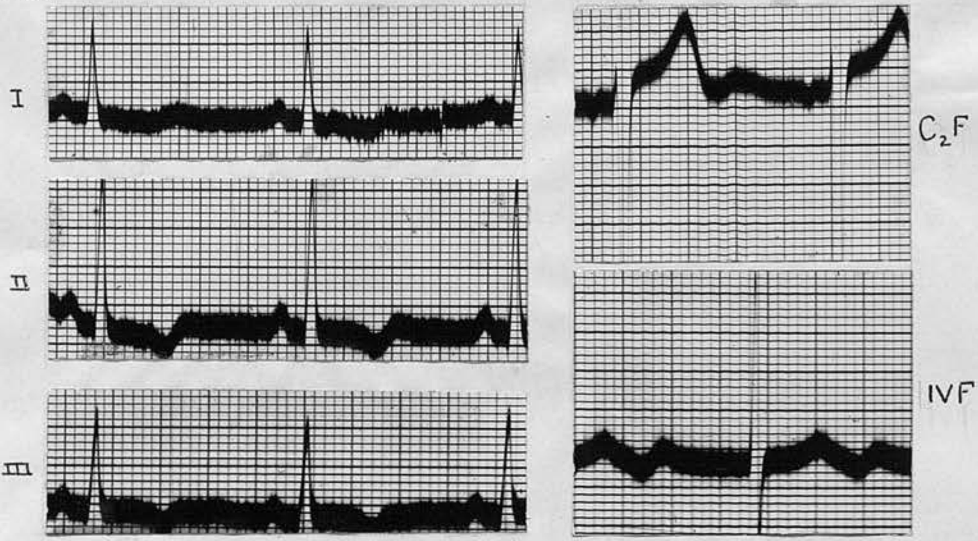
CASE 4. MRS A.F. aet. 44

Fig 1.



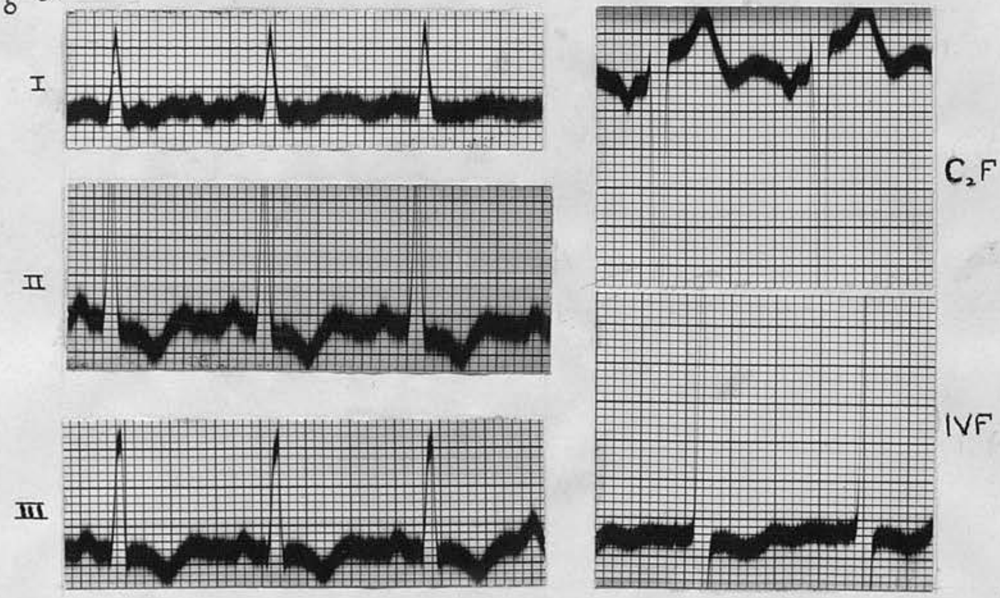
Pre-sympathectomy

Fig 2.



Pre-sympathectomy: 3 months later

Fig 3.



3 years post-sympathectomy

Case 4. Mrs. A.F. Aet 44

The main complaint of this patient was, again, of severe headaches. Her pre-operative basic diastolic pressure was 110 mm Hg.; there was no cardiac failure, but slightly impaired renal function and grade II retinae. She was of average physique.

The two pre-operative E.C.G. records are of interest; three months elapsed between them and during this time deterioration has occurred. T in lead I from being low upright has become shallow inverted; T in lead II from being upright has become sharply inverted, and T in lead III has also, from being upright, become steeply inverted. In IV$_4$F a previously upright T (7 mm high) has become diphasic (+ -).

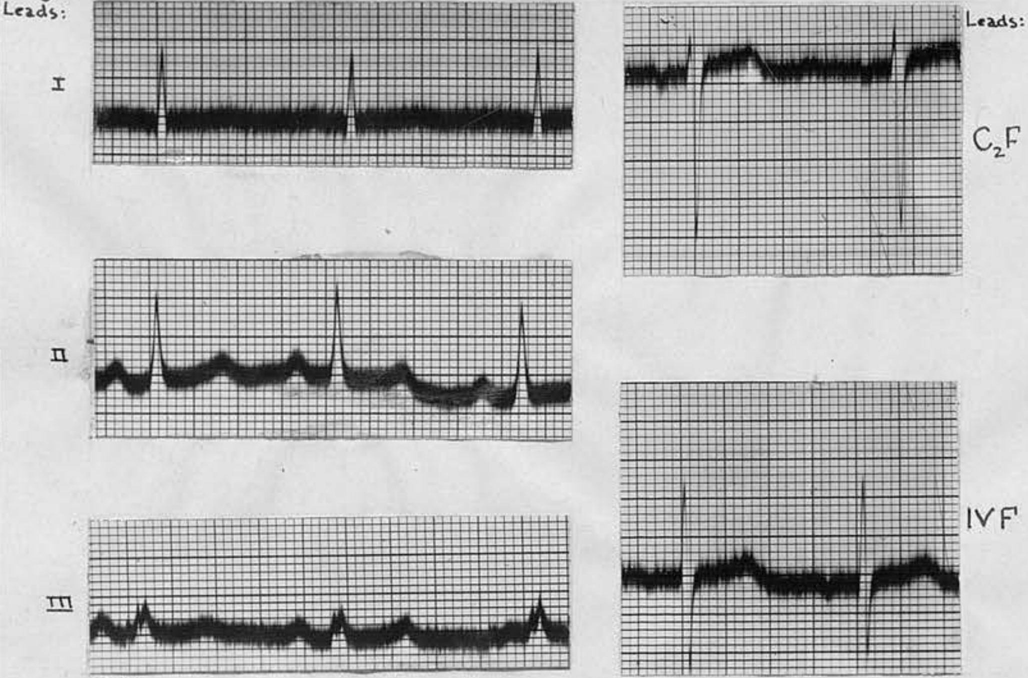
In the post-operative record T in lead I has again become flat, but lead II shows ST depression and T inversion of the type associated with marked left ventricular hypertrophy.

At the time when this last record was taken, 3 years after sympathectomy, the patient who had been relieved for over 2 years, was again deteriorating and in fact developed a grade IV retinopathy a few months later and died of renal failure.

Her electrocardiograms are of interest chiefly in that they show evidence of downhill progress in the three months prior to operation. Unfortunately we have no record at a year after her sympathectomy.

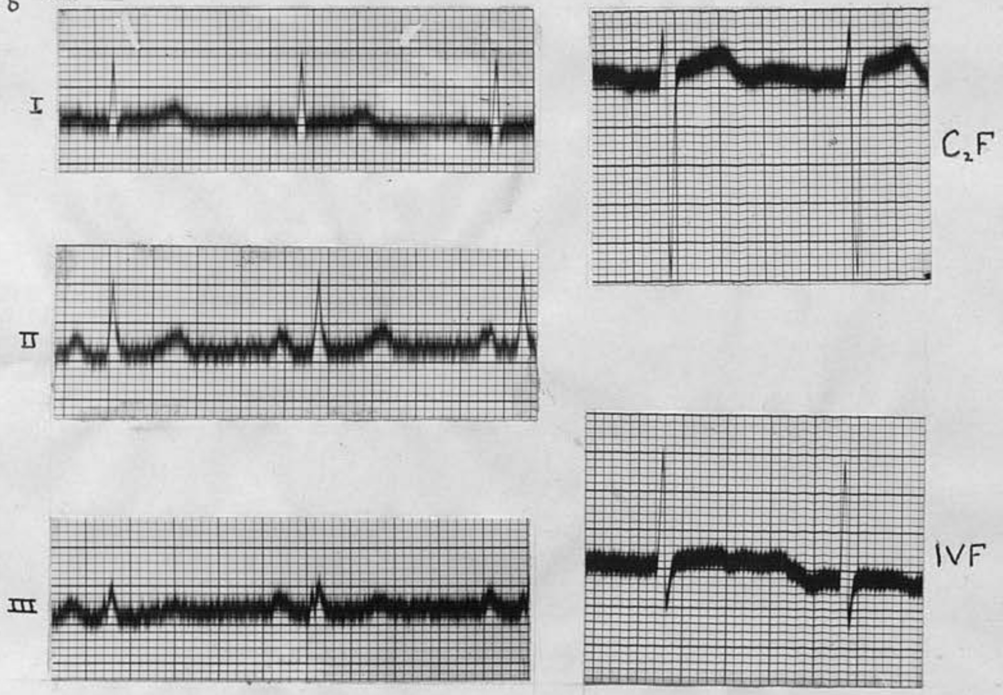
CASE 5. Miss B. H. aet. 30

Fig 1.



Pre- sympathectomy

Fig 2.



3 years post-sympathectomy

Case 5. Miss B.H. aet. 30

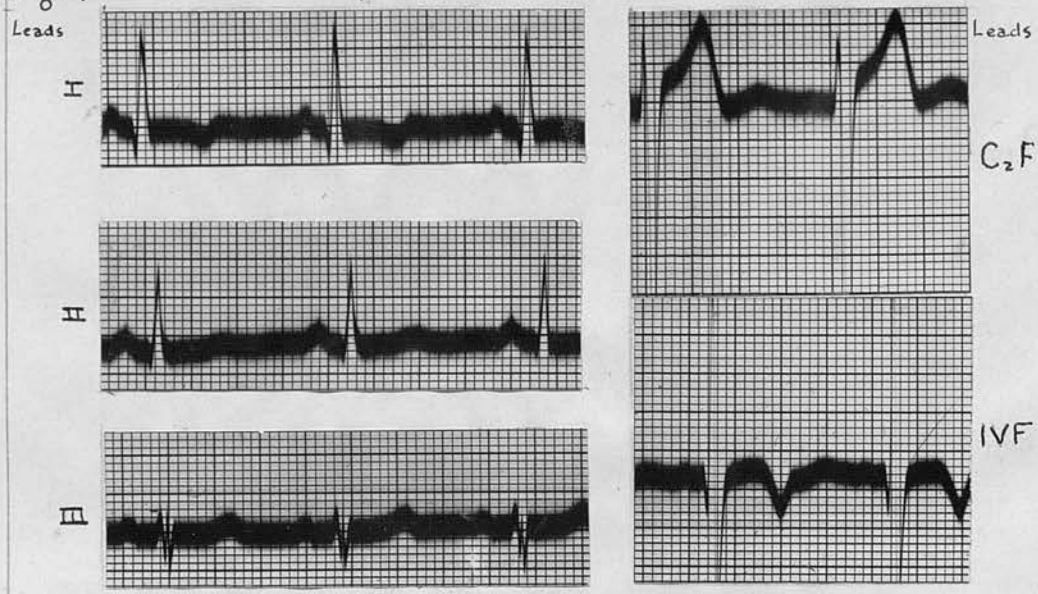
The pre-operative complaints of this rather asthenic young woman were of headache and palpitation. Her basic diastolic pressure was 95 mm Hg., her retinae grade I and her cardiac and renal efficiency normal.

The pre-operative E.C.G. shows a flat T in lead I. In the post-operative record taken three years after sympathectomy, T in lead I is upright.

Clinically the patient's symptoms are less severe and she is fit for work.

CASE 6. D.S.L., male aet. 35

Fig 1

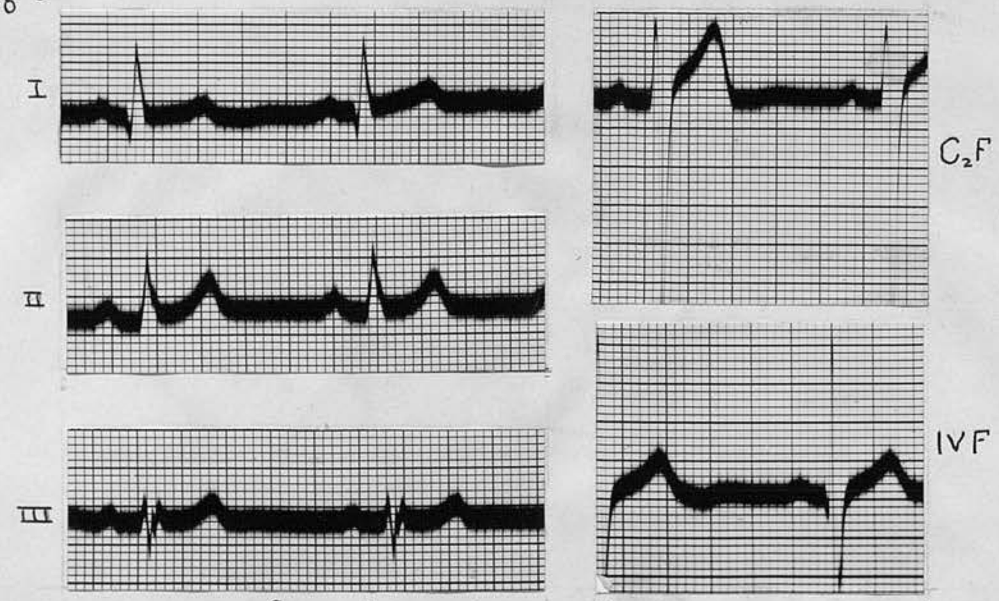


Pre-sympathectomy

Fig 2.

3 months post-sympathectomy

Fig 3.



8 months post-sympathectomy

Case 6. D.S.L. Male aet. 35

This R.A.F. sergeant, who was tall and heavily-built, complained of headaches, dizziness and occasional "black-outs". His basic diastolic pressure was 120 mm Hg., retinae grade II, renal function very slightly impaired, heart slightly enlarged (28%) but no cardiac failure.

The pre-operative E.C.G. shows sharply inverted T in lead I, flat T in lead II and steep sharp T inversion in lead IVF.

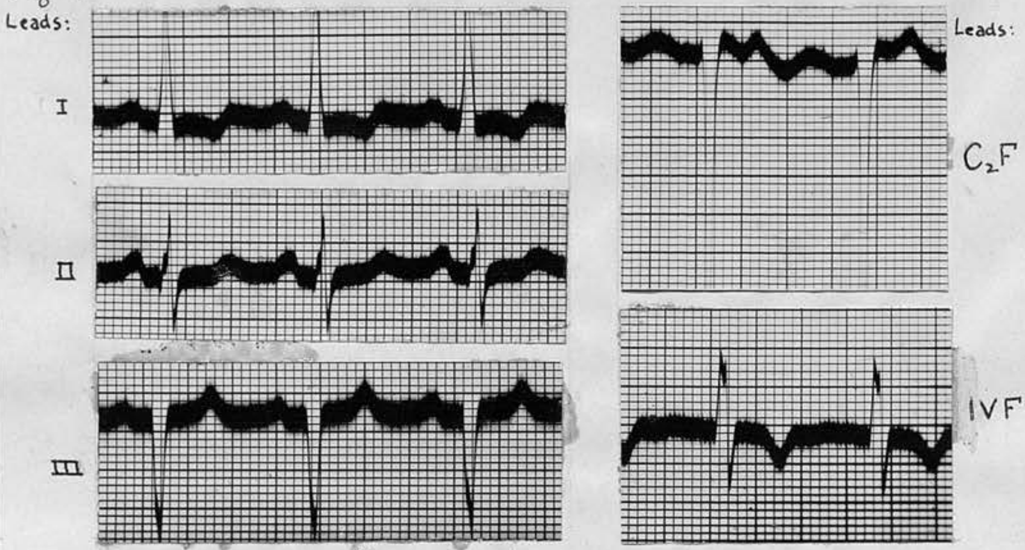
At 3 months after operation the record shows an upright T in leads I and II and a slurred upright T in IVF.

A later record, 8 months after operation, shows an increase in the heights of the T waves in leads I and II and a more sharply upright T in lead IVF.

Symptomatically and objectively the patient has improved: the basic diastolic pressure at 12 months after operation is 90 mm Hg., renal function normal, and retinae still grade II. His cardiac enlargement has decreased from 28% to 14%.

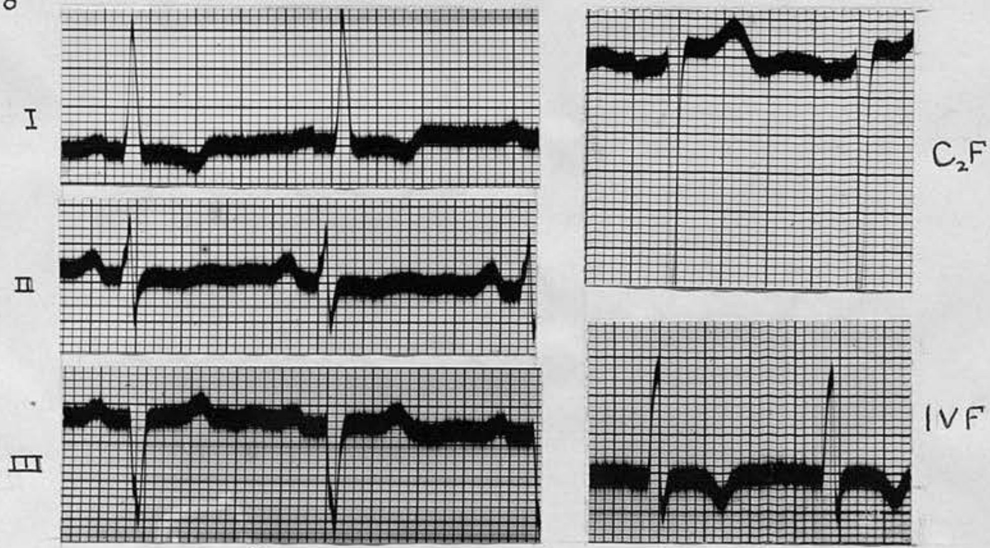
CASE 7. Miss J.N. aet. 53.

Fig 1.



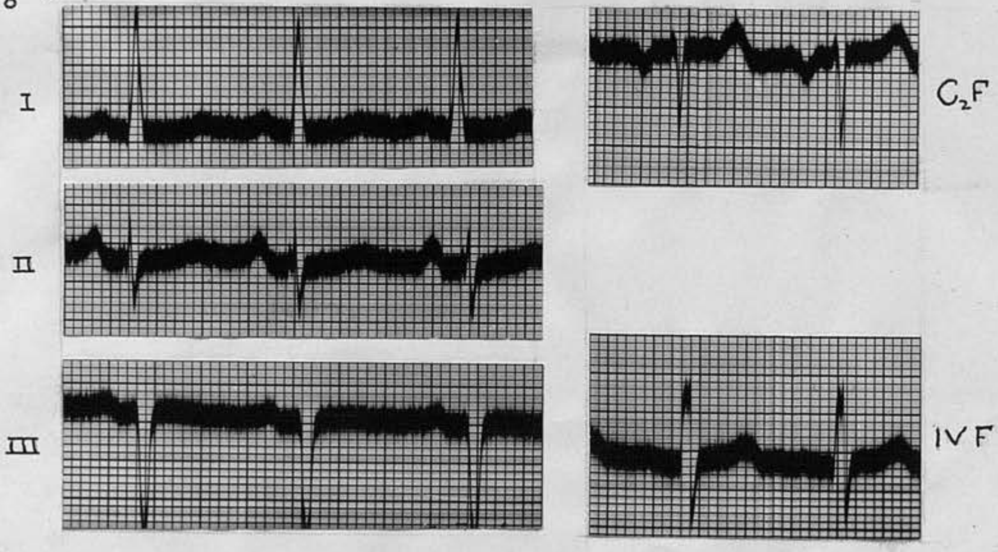
Pre-sympathectomy

Fig 2.



Pre-sympathectomy: 1 month later

Fig 3.



11 months post-sympathectomy

Case 7. Miss J.N. aet. 53

This patient had had mild symptoms of cardiac failure for months, and complained of diplopia one day before admission. Her basic diastolic pressure was found to be 130 mm Hg., retinae were grade I, renal function normal but cardiac efficiency slightly impaired. She was of average build.

Her two pre-operative E.C.G. records are separated by an interval of one month. There is the typical pattern of left ventricular hypertrophy in standard lead I in both records, but during the month there has developed an ST depression of 1 mm. in lead II.

The final record, taken 11 months after operation, shows an upright T in leads I, II and IVF, and the ST segment in lead II is again normal. At this time, however, the patient's symptoms were not materially relieved and she was developing early congestive cardiac failure. Hence an E.C.G. improvement is not necessarily a reflection of clinical improvement.

Case 8. Mrs. J.R. aet. 34

This patient resembles Case 1 in that she presented as a case of cerebral haemorrhage consequent on headaches. In her case it resulted in right-sided hemiplegia. Her basic diastolic pressure was 140, retinae and cardiac efficiency normal, renal function slightly impaired. She was underweight.

Her pre-operative E.C.G. records show flattened T in lead I, ST depression in lead II followed by an inverted T, and in IVF T is diphasic (+ -), chiefly inverted.

Two months after operation T is sharply upright in all standard leads, there is ST elevation in lead II, and a sharply upright T in lead IVF.

At 11 months after sympathectomy leads I and II are normal; T in IVF is now 11 mm tall.

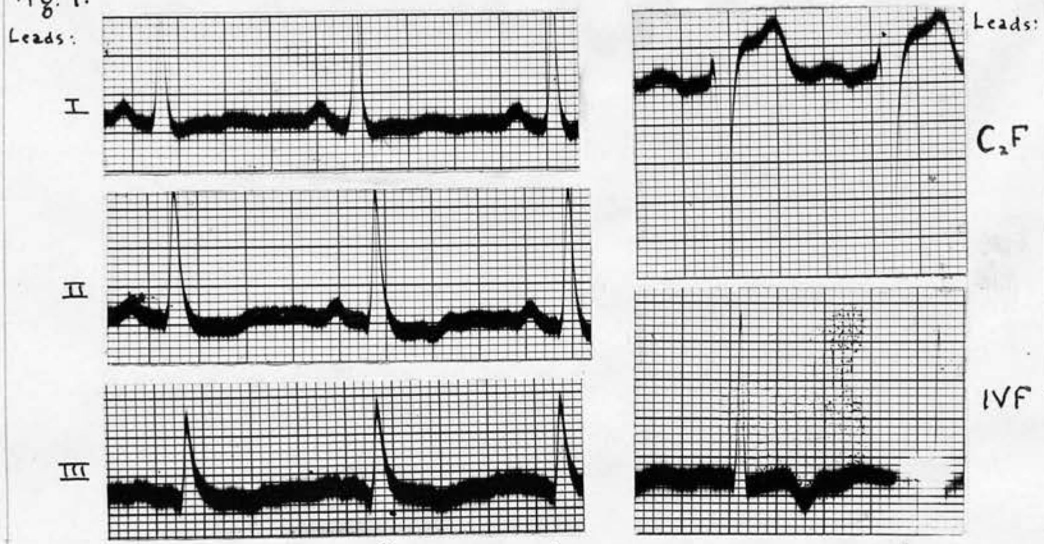
At 17 months after operation there is no change in the standard leads, and complete normality in the unipolar chest leads (which had now replaced the leads C_2F, IVF previously employed).

Clinically at 17 months post-sympathectomy the patient is symptom-free, and can do all her housework, managing to overcome her disabilities with great ingenuity. Her basic diastolic pressure is 116 mm Hg., retinae grade I and there is still very slight impairment of renal function.

At this period unipolar limb leads show the heart to be in an intermediate position, and unipolar praecordial leads show no evidence of left ventricular hypertrophy.

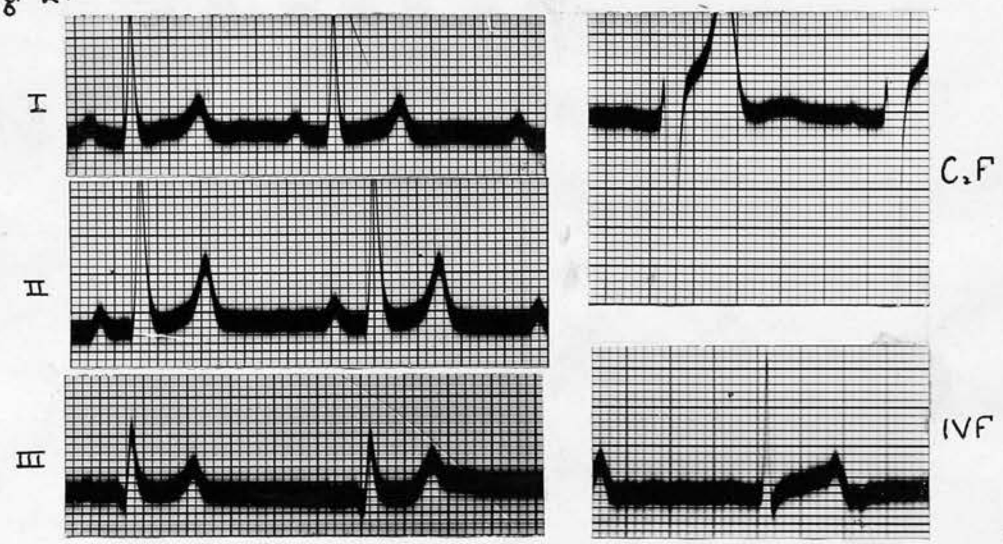
CASE 8. MRS J. R. aet. 34

Fig. 1.



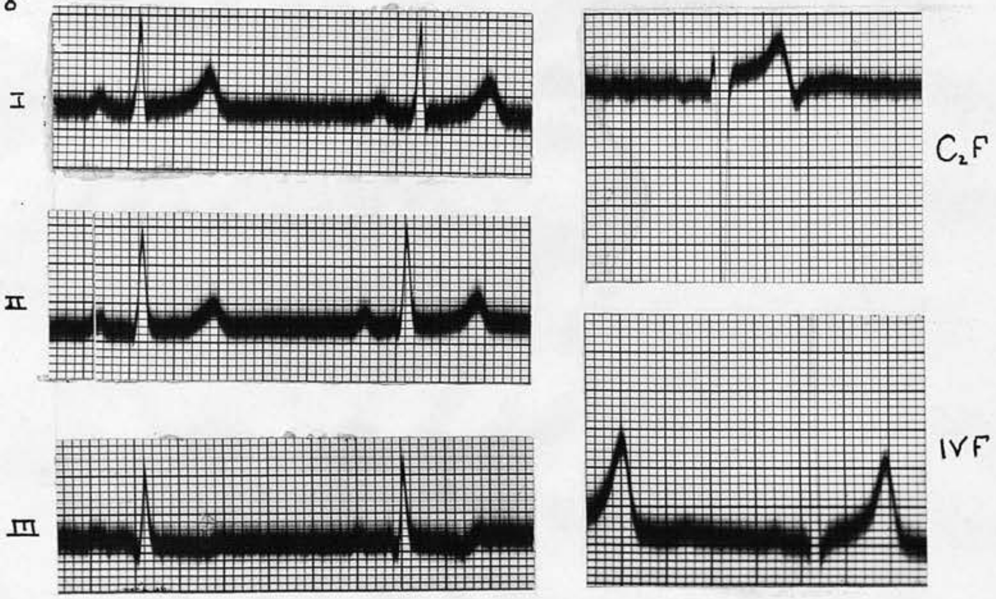
Pre-sympathectomy

Fig. 2.



2 months post-sympathectomy

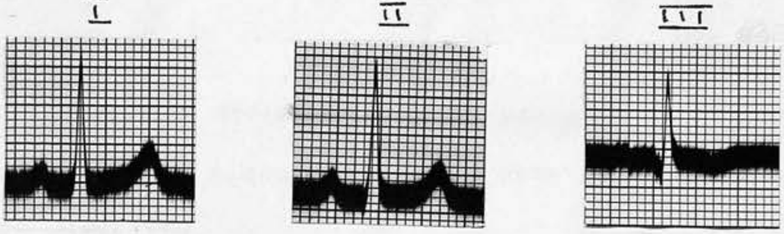
Fig. 3.



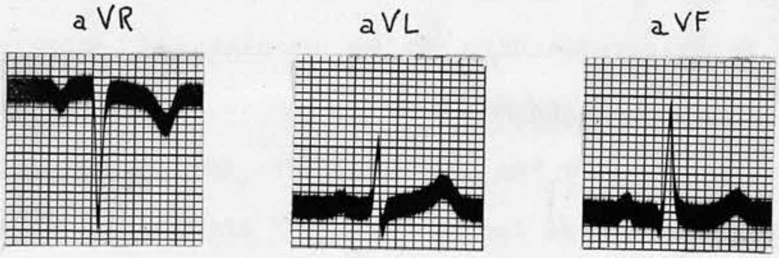
11 months post-sympathectomy

Case 8 continued

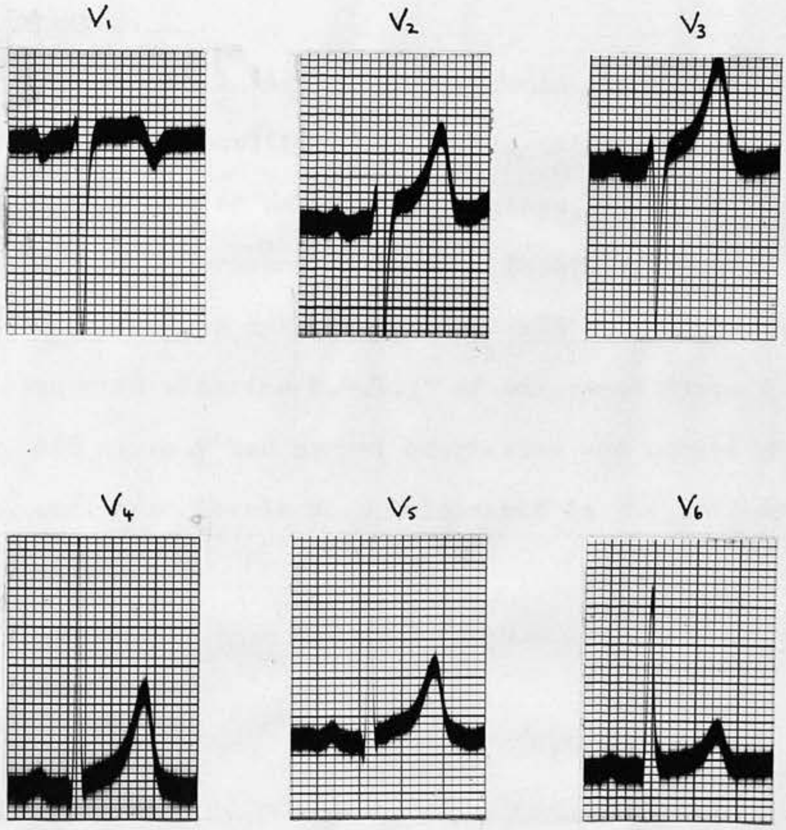
Fig. 4



Unipolar Limb Leads



Unipolar Chest Leads



17 months post-sympathectomy

In all but one of those 8 illustrative cases clinical improvement has been associated with a return of the E.C.G. pattern to normality.

It has been found by White and his co-workers (67) that post-operative improvement in the electrocardiograms of sympathectomised patients correlated with deterioration, and not with improvement, in retinal grade; and also that there is no correlation between the renal function and the electrocardiogram. Those writers also found that improvement in the E.C.G. was not precluded by the presence of cardiac enlargement, a long history of hypertension, or the fact that the patient belonged to a higher age-group.

In our small series we have found that the factor giving the greatest positive correlation with electrocardiographic improvement was that of subjective symptoms, the next in order being the diastolic pressure and renal function.

Cardiac size and efficiency would be expected to be closely connected with the E.C.G.: of our cases whose E.C.G. improved, 63% already had normal heart-size and normal cardiac function, and these levels were maintained in the post-operative period.

2. Heart Size

As we have reported in an earlier section of this paper, observations on heart-size were made on many of our cases initially and after 12 months of surgical or medical treatment.

The method (of Ungerleider and Gubner) which we employed of measuring the frontal cardiac area on an X-ray of the heart taken by a standard technique has also been described, and a reference given (62) to the paper from which the method was obtained.

It was fully realised by radiologists and clinicians how fallible was this means of obtaining an estimate of the heart-size, but it was decided that in the long run most of the errors would cancel each other out, and that as the same individuals carried out the radiographic work and the cardiac measurement in each case, any residual error would at least be constant.

With regard to the medically-treated cases who were re-examined after 12 months treatment, there was no fallacy or "snag" about the second examination to cloud the issue and render the result open to doubt. Matters were very different, however, when the surgical cases were re-examined, as we hope to demonstrate.

For these cases, at the post-sympathectomy examination, care was taken to put no weight on a cardiac measurement made at less than six months after operation. Earlier post-operative measurements frequently revealed a striking diminution in heart-size, but by taking the precaution of recording the patient's blood-pressure and pulse-rate at the moment of X-ray, as was done at the initial examination, it was found that this early phenomenon was invariably associated with orthostatic hypotension and tachycardia/

tachycardia, whereas by the time six months had elapsed since operation these circulatory abnormalities had disappeared.

Is there any justification for the belief that this immediate post-operative decrease in heart-size is in fact due to the observed abnormalities of blood pressure and pulse rate?

In order to clarify this problem, several individuals, normal and hypertensive, were subjected to a small experiment now to be described.

It was realised that the circulatory phenomena noted soon after sympathectomy, when the individual rose to the erect position (as he had to do when being X-rayed), were practically identical with those which are recorded in persons to whom a nitrite preparation has been administered, and who are subsequently made to stand erect when the drug is having its maximum effect (68).

We persuaded 5 untreated cases of essential hypertension and 4 normal males of ages 25-30 to co-operate in this experiment. (Many more cases were of course desirable but the experiment came to an untimely end owing to a sudden acute shortage of X-ray film)

Each person had a routine antero-posterior film taken of his heart as described earlier, the radiographers taking the films being those who co-operated so helpfully during the whole investigation.

The blood-pressure and pulse rate were then recorded while the individual remained standing at the X-ray screen.

He was then given glyceryl trinitrate orally in a dosage of gr.1/100 to 1/50 according to his stature, and when the drug appeared to be achieving its maximal effect (which usually happened/

happened in 3 to 4 minutes, the patient becoming flushed, complaining sometimes of headache or palpitation, and showing a rise in pulse rate and a drop in the systolic pressure) the subject was once more led to the X-ray screen, another exposure taken, and the blood pressure and pulse rate again recorded immediately afterwards with the individual still in the erect position.

A summary of the results of these investigations is shown in Table 43. From these we see that in every case the frontal cardiac area has diminished after the administration of nitrite; in every case the pulse rate has increased and in all but two cases (where it remained unchanged) the pulse pressure has diminished.

Admittedly the percentage decrease in the frontal cardiac area is no case very great, and it is open to question whether any change less than 10% is in fact significant. Yet the fact that over the whole series the trend is in the same direction tends to suggest that it is in some way a result of the circulatory phenomena induced by the glyceryl trinitrate.

As we have noted earlier, the effects of nitrite on the circulation - narrowing of the pulse-pressure due to a drop in the systolic pressure, and tachycardia - are exactly those changes noted in a patient who has recently been subjected to lumbo-dorsal sympathectomy, when he is moved from the lying or sitting position into the erect position. Hence it is highly probably that the diminution in heart-size noted radiologically at this early post-operative examination is not a true picture of the actual cardiac area, but is falsified by poor cardiac filling due, in turn, to a poor venous return to the heart.

If/

TABLE 43

A. Normal Adults - Males, aet. 25-30

Case		B.P.	PP	% change in P.P.	Pulse rate	% change	Frontal cardiac area	% change
1.	(Before							
	(Nitrate	132/96	32	decr.	96	incr.	150sq.cm.	decr.
	(After			by		by		by
	(Nitrate	100/90	10	68.7%	130	45.8%	128 " "	14.7%
2.	(Before							
	(Nitrate	140/84	56	decr.	68	inçr.	149 " "	decr.
	(After			by		by		by
	(Nitrate	115/94	21	62.5%	100	47%	142 " "	4.7%
3.	(Before							
	(Nitrate	130/96	34	decr.	80	incr.	137 " "	decr.
	(After			by		by		by
	(Nitrate	104/94	10	70.6%	112	40%	127 " "	7.3%
4.	(Before							
	(Nitrate	130/90	40	decr.	72	incr.	131 " "	decr.
	(After			by		by		by
	(Nitrate	115/90	25	37.5%	104	44%	117 " "	10.7%

(continued on next page)

TABLE 43
(cont.)

B. Adult cases of essential diastolic hypertension

Case		B.P.	PP	% change in P.P.	Pulse rate	% change	Frontal cardiac area	% change
1. (M. 36)	(Before Nitrate	170/150	20	decr. of 10%	120	incr. of 16.6%	126sq.cm.	decr. of 4.6%
	(After Nitrate	158/140	18		140		120 " "	
2. (F. 62)	(Before Nitrate	240/108	132	decr. of 59%	68	incr. of 29.4%	151 " "	decr. of 6.6%
	(After Nitrate	164/110	54		88		141 " "	
3. (M. 44)	(Before Nitrate	250/150	100	no change	88	incr. of 18.2%	164 " "	decr. of -6.7%
	(After Nitrate	250/150	100		104		153 " "	
4. (F. 43)	(Before Nitrate	234/154	80	decr. of 15%	100	incr. of 40%	124 " "	decr. of 8.8%
	(After Nitrate	212/150	62		140		113 " "	
5. (F. 45)	(Before Nitrate	260/140	120	no change	88	incr. of 36.3%	149 " "	decr. of 6.7%
	(After Nitrate	230/150	120		120		139 " "	

Table 43: To show change in pulse pressure (P.P.), pulse rate and frontal cardiac afea after the administration of glyceryl trinitrate by mouth.

If a heart-size estimation carried out at a date later than six months after sympathectomy reveals the frontal cardiac area to be still less than that found pre-operatively, then this can be accepted as true, and the diminution attributed probably to a reduction of pre-operative cardiac dilatation. This answer to the problem is more likely to be correct than that which postulates actual reduction in the bulk of a hypertrophied left ventricle. Short of carrying out cardiac volume investigations the problem cannot be finally solved.

In our present series of surgical and medical cases, only 36 surgical and 38 medical were tested both initially and at the 12-months follow-up. For these cases the subsequent behaviour of the constituent members of each of the pre-treatment grades A, **B**, C and D is shown in Table 44, and the percentage of each grade, surgical and medical, which improved, deteriorated or remained unchanged at the 12-months follow-up examination is set out in Fig. XXXVII.

Grade B shows the greatest difference between the surgical and medical group, a difference which is in favour of surgical treatment. Of the surgical cases 27.3% improved, as against 9.5% of the medicals; no surgical case deteriorated, as against 9.5% of the medical cases.

With regard to the malignant cases, 8 surgical and 13 medical had a pre- and post-treatment measurement.done. For the 8 surgical cases the pre-treatment distribution was:

Grade A: 1 case which remained A
" B: 4 cases " " B
" C: 3 cases, 2 of which remained C and 1 improved to B.

TABLE 44

Surgical Cases (benign only)

Pre-treatment		Post-treatment							
Heart-size Grade	No.of cases	Improved			No change	Deteriorated			Total
		+++	++	+		-	=	≡	
A	9	-	-	-	9	-	-	-	9
B	22	-	-	6	16	-	-	-	16
C	5	-	1	1	3	-	-	-	5
D	-	-	-	-	-	-	-	-	-
Total:	36	-	1	7	28	-	-	-	36

Medical Cases

Pre-treatment		Post-treatment							
Heart-size Grade	No.of cases	Improved			No change	Deteriorated			Total
		+++	++	+		-	=	≡	
A	14	-	-	-	13	1	-	-	14
B	21	-	-	2	17	2	-	-	21
C	3	-	-	1	2	-	-	-	3
D	-	-	-	-	-	-	-	-	-
Total:	38	-	-	3	32	3	-	-	38

Table 44: To show, (for benign cases only) the subsequent change effected on the constituents of each initial heart-size grade, by surgical and medical treatment respectively.

FIG. XXXVII

Fig. XXXVII: To show the percentage of each pre-treatment heart-size grade which had improved, deteriorated or remained unchanged at the 12.months follow-up examination.

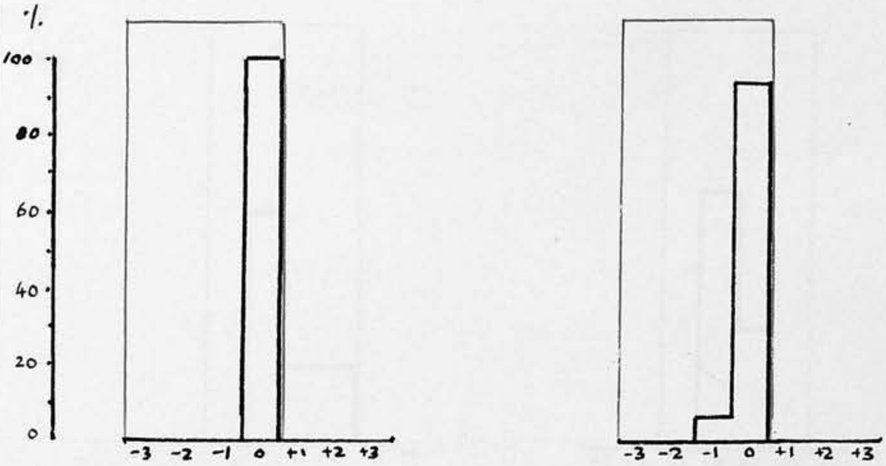
Key to diagram:

+1, +2, denote improvement by one or two grades respectively

-1, -2, " deterioration " " " " " "

0, denotes no change.

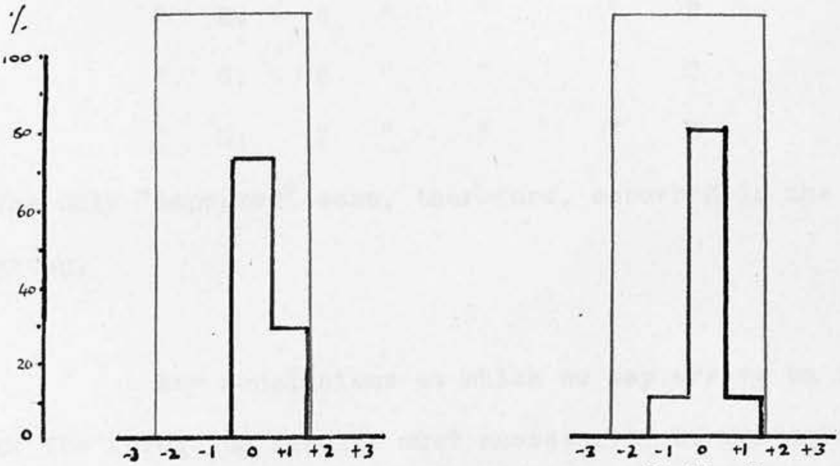
Pre-treatment Heart-size Grade A



Surgical
(9 cases)

Medical
(14 cases)

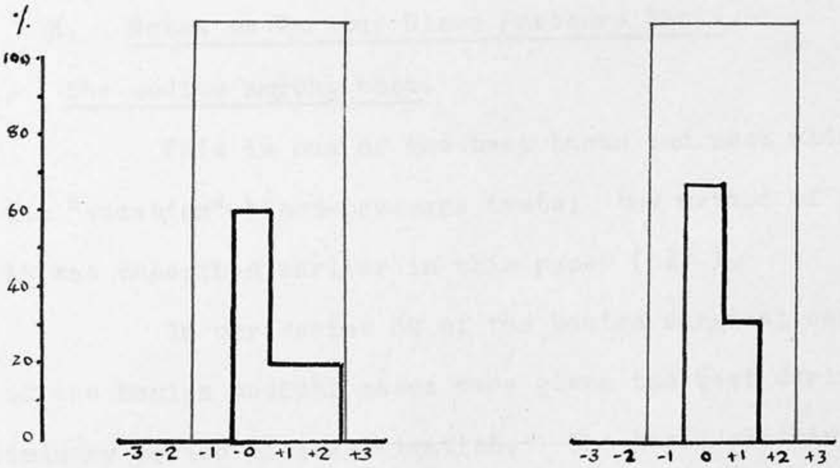
FIG. XXXVII (cont.)



Pre-treatment Heart-size Grade B

Surgical (22 cases)

Medical (21 cases)



Pre-treatment Heart-size Grade C

Surgical (5 cases)

Medical (3 cases)

Of the 13 medical cases:

Grade A: one case which remained A
" B: 4 " " " B
" C: 6 " " " C
" D: 2 " " " D

The only "improved" case, therefore, occurred in the surgical group.

Any conclusions at which we may arrive on the basis of the foregoing results must necessarily be tentative in view of the small numbers. Surgery, however, seems again to have more to offer than medical treatment, since such cases who have decrease in heart size after 12 months have occurred more frequently in the surgical than in the medical groups, the actual figures being as shown in Table 45, for the benign cases.

The illustrative X-rays will be found in the Appendix.

3. Notes on Various Blood Pressure Tests.

A. The sodium amytal test.

This is one of the best known and most widely used of the "sedation" blood-pressure tests; the method of performing it was described earlier in this paper (p23).

In our series 39 of the benign surgical cases and 48 of the benign medical cases were given the test during the preliminary period of investigation. The basic sleeping diastolic pressures achieved were classified in groups as we noted earlier, but repeat here for convenience:

Basic sleeping D.B.P. below 90 mm Hg. Grade I
" " " 90-99 " " " II
" " " 100-109 " " " III
" " " 110-119 " " " IV
" " " 120 and over " V

TABLE 45

		Improved	No change	Deteriorated
Initial Grade A	(Surgical	-	100%	-
	(Medical	-	93%	7%
Initial Grade B	(Surgical	27.3%	72.7%	-
	(Medical	9.5%	81.0%	9.5%
Initial Grade C	(Surgical	40%	60%	-
	(Medical	33.3%	66.7%	-

Table 45: To show change in each initial heart-size grade after treatment.

The percentage distribution of these grades in the surgical and medical groups is shown in Fig. XXXVIII and from this diagram it appears that the medical group achieved on the whole a lower level of sleeping diastolic pressures than did the surgical. This is remarkable in view of the fact, now known to us, that it was the surgical cases who eventually achieved lower waking diastolic levels at the 12 months follow-up examination.

None of the medical group had the test repeated after a period of treatment, and only 11 of the benign 39 surgical cases did so. In those 11 patients, the subsequent amytal test produced the following results:

Two patients showed an increase in the sleeping diastolic pressure, one of +2 mm Hg., one of +4.mm Hg.

Two cases have maintained their, levels unchanged.

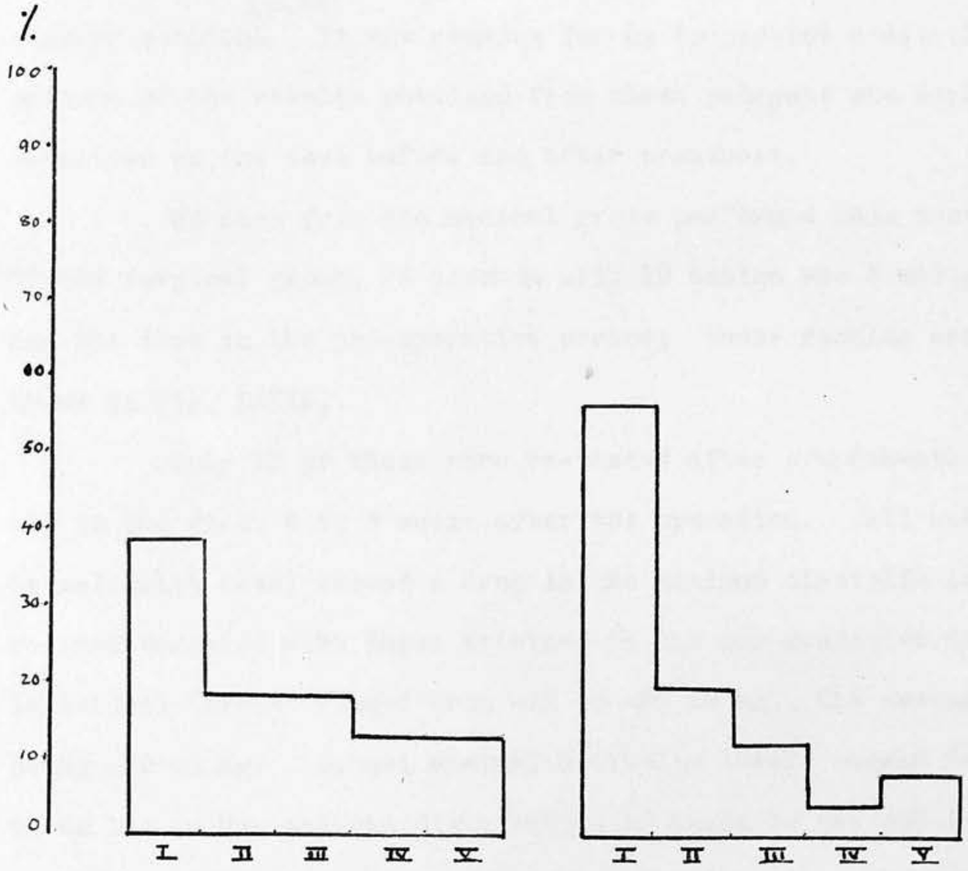
24,
Seven cases had dropped by -2, -14, -4, -36, -24/ and -14 mm Hg. respectively, i.e. an average drop of -13 mm Hg.

Sympathectomy therefore appears to lower the sleeping diastolic pressure as well as the waking level, though certainly our cases are far too few in number to generalise on this point.

The most important aspect of the Sodium Amytal test, however, is its use as a means of selecting patients for sympathectomy. This test, and others like it, have until the present time been relied upon/as heavily as any other preliminary investigation, if not more so, for such a purpose, and it is very much an open question whether such reliance is justified by results. This matter will be dealt with in greater detail in the last section of this paper, i.e. that which will be devoted to the whole problem of selection for sympathectomy.

B./

FIG. XXXVIII



Surgical
(39 cases)

Medical
(48 cases)

Fig. XXXVIII: To show the distribution over the 5 diastolic pressure grades of 39 surgical and 48 medical cases, during the Sodium Amytal sedation test (part of their initial examination).

B. The Cold Pressor Test.

This test, also, has been described in full in an earlier section (p.24). It now remains for us to present a detailed account of the results obtained from those patients who were submitted to the test before and after treatment.

No case from the medical group performed this test. Of the surgical group, 24 cases in all, 19 benign and 5 malignant, had the test in the pre-operative period; their results are shown in Fig. XXXIX.

Only 12 of these were re-tested after sympathectomy, all in the first 4 to 8 weeks after the operation. All but one (a malignant case) showed a drop in the maximum diastolic levels reached compared with those attained in the pre-operative test. Individual "drops" ranged from -12 to -60 mm Hg., the average being -29 mm Hg. Actual maximal diastolic levels ranged from 94 to 194 mm Hg. and the distribution of these is set out in Fig. XL, which shows also the pre-sympathectomy distribution of maximal diastolic levels attained during the test.

In the pre-operative period 100% of cases had a maximal diastolic level in the test of over 139 mm Hg; after operation only 58% were above this level. A reproduction of the difference between the pre- and post-operative test results for one individual is shown in Fig. XLI.

The cold pressor response is neurogenic, and due to a reflex constriction of the arterioles of the body in response to the stimulus of ice-water applied to one upper limb, and it is necessary that peripheral sensation be normal in the limb which is/

FIG. XXXIX

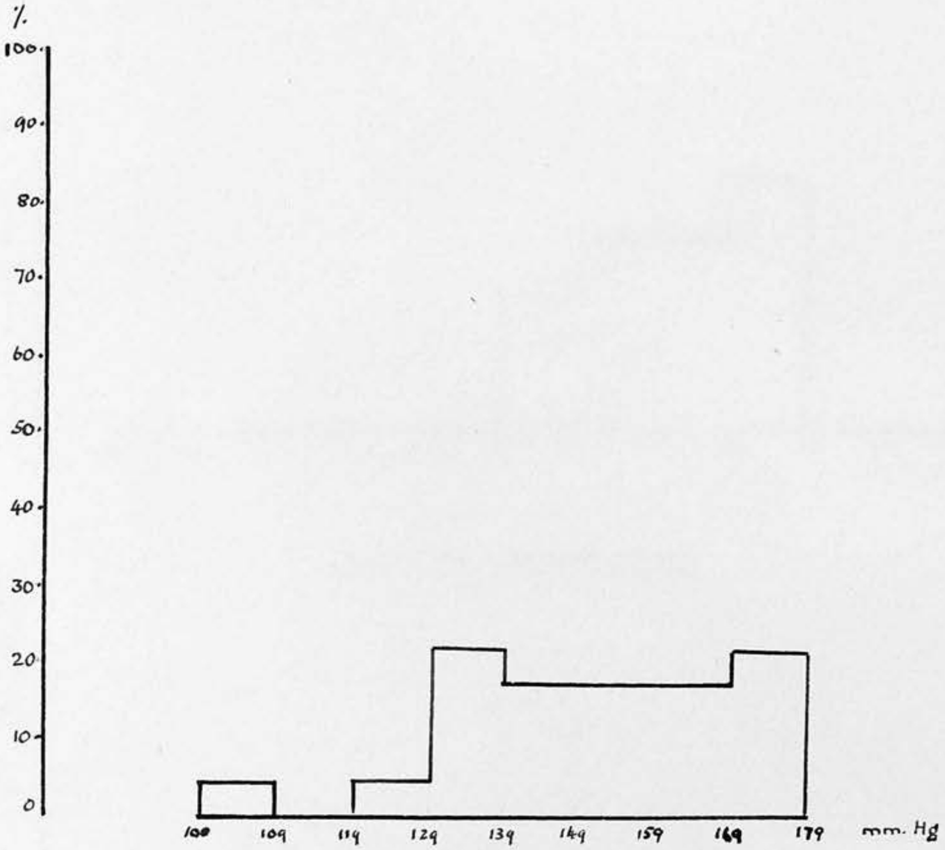
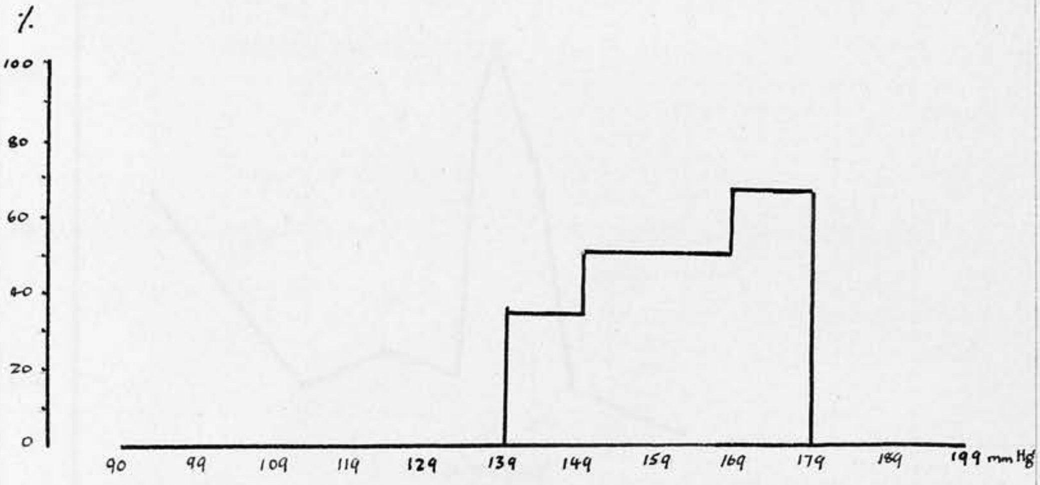


Fig. XXXIX: To show the percentage (of 24 surgical cases) who achieved maximum diastolic pressures from 100 to 179 mm Hg. during the cold pressor test in their initial examination.

FIG. XL

(a) Before Sympathectomy



(b) After Sympathectomy

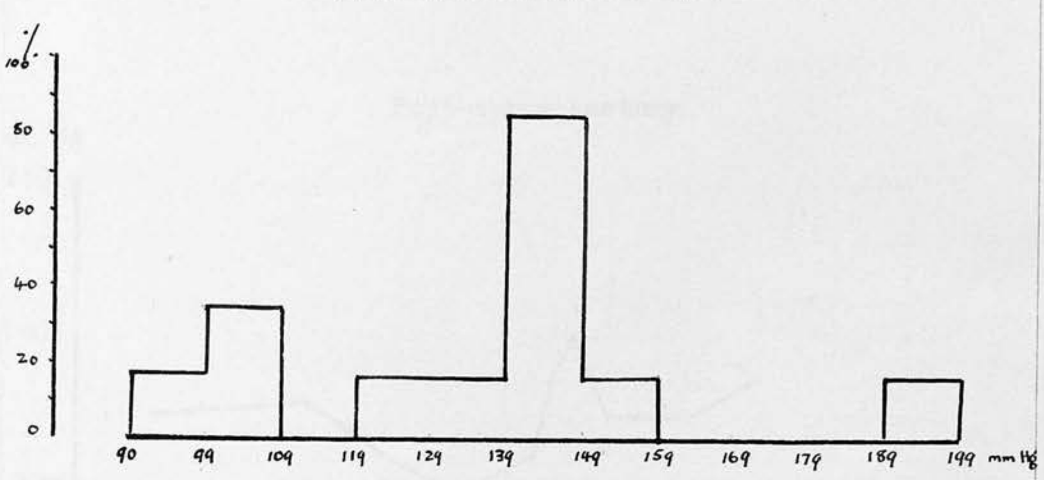
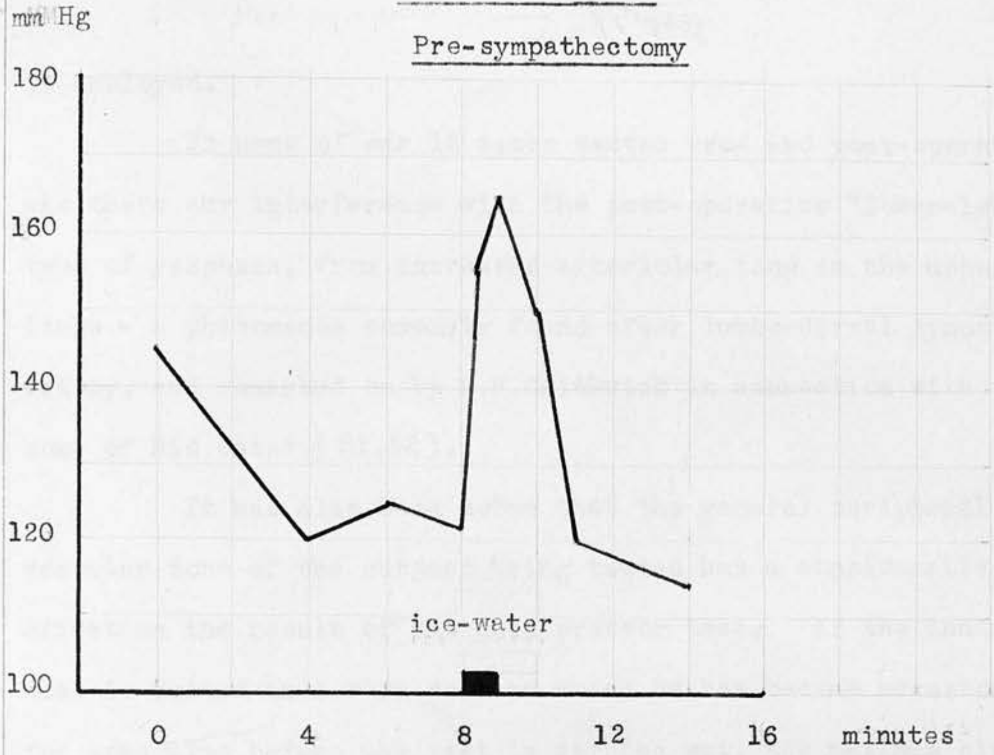
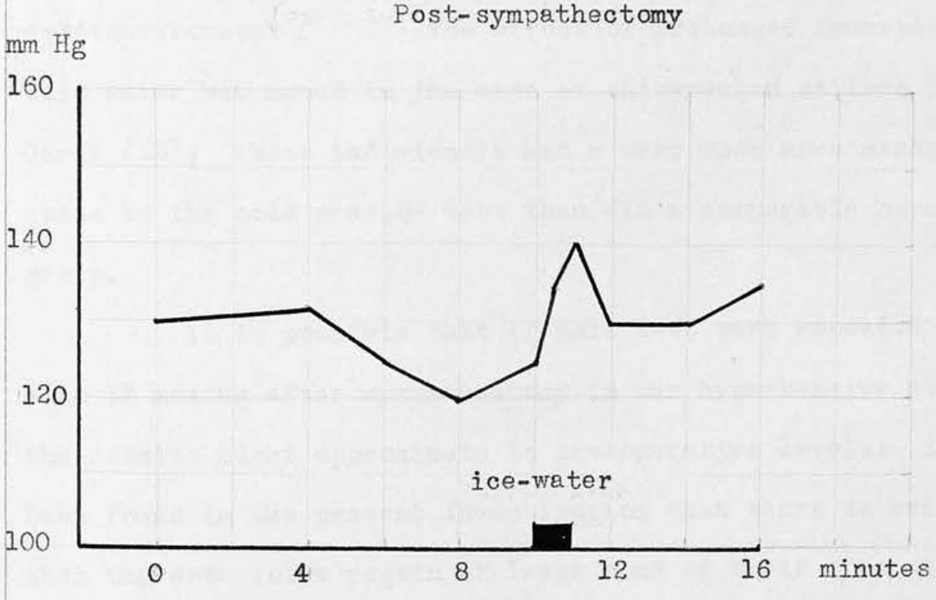


Fig. XL: To show the diminution in the maximum diastolic levels achieved by 12 surgical cases during the Cold Pressor Test after sympathectomy, compared with their results before sympathectomy.

FIG. XLI .



Pre-sympathectomy



Post-sympathectomy

Fig. XLI: Cold Pressor test results (diastolic pressure only) of a female aged 44 before and after lumbo-dorsal sympathectomy is employed.

In none of our 12 cases tested pre- and post-operatively was there any interference with the post-operative "lower-level" type of response, from increased arteriolar tone in the upper limbs - a phenomenon commonly found after lumbo-dorsal sympathectomy, and remarked on by R.H.Smithwick in connection with some of his cases (51,52).

It has also been noted that the general peripheral vascular tone of the subject being tested has a considerable effect on the result of the cold pressor test. If the individual is tested in a warm room to which he has become accustomed for some time before the test is carried out, the maximum blood pressure level attained is lower than if he were tested in a cold environment. The effect of prolonged immersion in cold water was noted in the case of shipwrecked sailors by Garai (22); these individuals had a very much more marked response to the cold pressor test than did a comparable normal group.

It is possible that if this test were repeated at, say, 6 to 12 months after sympathectomy in our hypertensive series the results might approximate to pre-operative levels: it has been found in the present investigation that there is evidence that the arterioles regain at least some of their tone at that period (see the next section on "posture blood pressure") on the evidence of the response of the blood pressure to tilting table tests.

This investigation includes far too few cases for the

results/

results to be significant, but they give an indication of a point which might with benefit be further investigated with larger numbers of cases.

As it stands,the post-operative cold pressor test offers a fairly satisfactory indication of whether the sympathectomy has been effective.

C. The Postural Blood Pressure Test using the Tilting Table.

When a normal individual is suddenly changed from the horizontal to the vertical position, whether actively, by his own muscular contraction, or passively lying on a tilting table, certain adjustments are made by his circulatory system, of which evidence is given by changed in blood pressure and pulse rate(55).

The systolic pressure in such circumstances falls by about 5 mm Hg., the diastolic rises by 5 to 10 mm Hg., and the pulse rate as a rule increases by about 10 to 12 per minute.

The circulatory dynamics underlying these changes are as follows: tilting into the erect position is followed by a constriction of the arterioles in order, as it were, to maintain the blood·flow back to the heart and prevent pooling of blood in the dependent parts of the body. The venous system, however, does not constrict and there is therefore some residual pooling which diminishes the venous return to the heart. This in turn causes poor filling of the heart during diastole, a lowered stroke/

stroke-volume and consequent tachycardia. Should the individual have any gross abnormality of his venous system (e.g. a marked degree of varicosity in the lower limbs) or should the arteriolar tone of the lower part of the body be temporarily diminished as it is after lumbo-dorsal sympathectomy, there is naturally a gross degree of blood-pooling in those areas, the venous return is much diminished, cardiac filling and output very poor indeed, and tachycardia of the order of 160-200 per minute may result in an effort of the body to prevent cerebral anoxaemia. If the individual is kept in the erect position this vicious circle ends in a minute or two in syncope due to cerebral anoxaemia, but if the patient is restored to the horizontal position normal conditions are restored instantaneously.

If a patient is tested on the tilting table within 2 or 3 weeks after sympathectomy, the graph shown in Fig. XLII is typical of the resulting blood pressure and pulse findings.

An earlier test, say, when the patient first stands up after his operation, might show a sharp fall in the systolic pressure, even to 90 or 80 mm Hg., an unreadable diastolic pressure and an almost uncountable pulse rate of the order of 180 per minute.

At 1 to 2 months after operation the results are less dramatic: the systolic pressure drops slightly, there is little or no diastolic drop and only a moderate degree of tachycardia. It is assumed that the denervated arterioles have regained at least some of their tone (suggested by the maintained diastolic pressure) and therefore any faintness and tachycardia experienced now must be due to dilatation and pooling on the venous side of the circulation.

The/

FIG. XLII

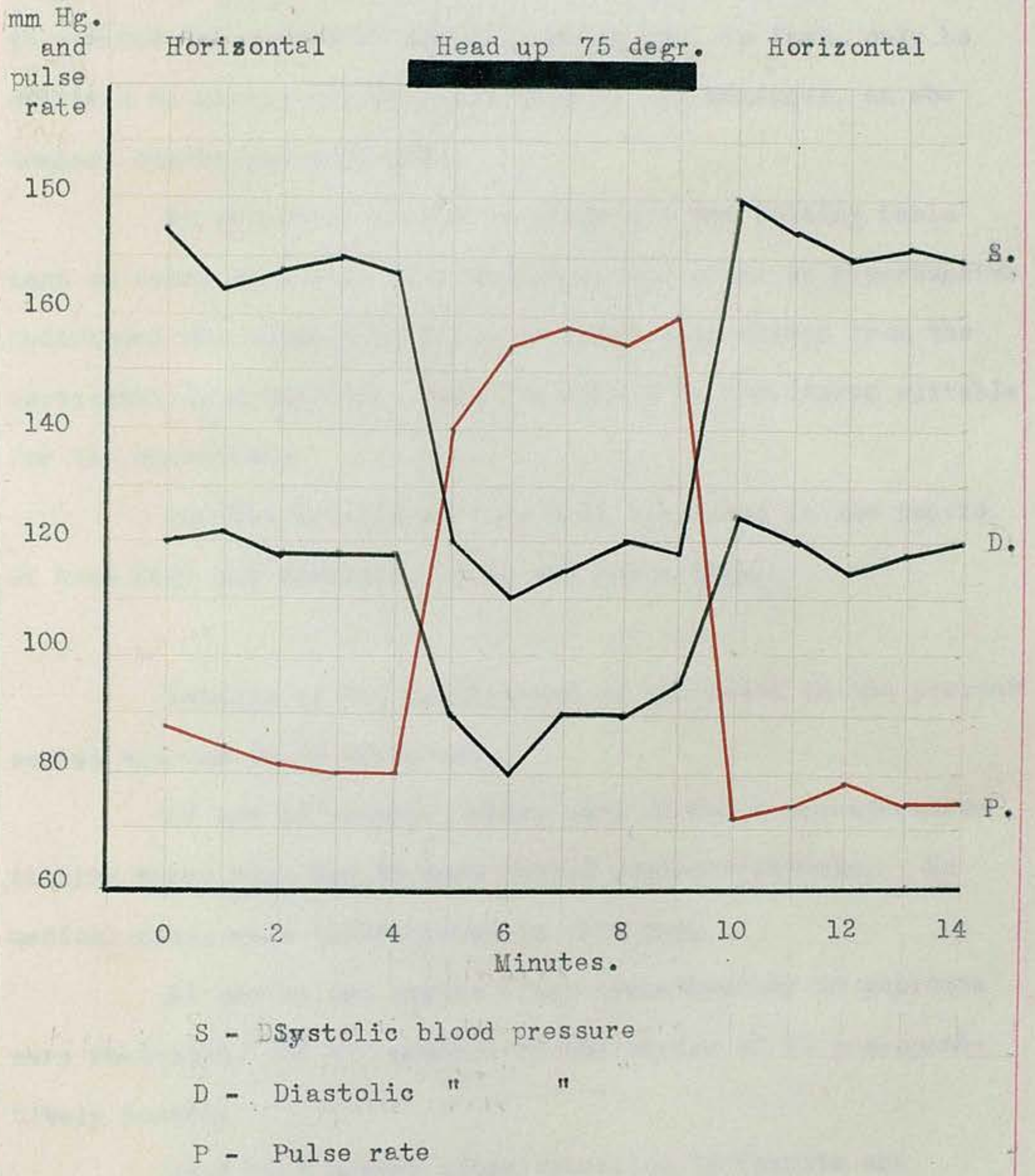


Fig. XLII: To show the effect of tilting on the blood pressure and pulse rate 2 weeks after lumbo-dorsal sympathectomy

The ineffectiveness of sympathomimetic drugs to relieve dizziness under these circumstances is understandable: they merely accentuate the tachycardia and do little or nothing to correct the venous abnormality which can, in fact, only be relieved by mechanical measures such as leg bandages, an abdominal binder and such like.

It should be a rule to carry out the tilting table test on every candidate for sympathectomy, since no hypertensive individual who shows a tendency to faint when tilted from the horizontal into the erect position should be considered suitable for the operation.

Further details of this test are found in the papers of Roth (48) and Gambhill, Hines and Adson (21).

Details of the performance of the cases in the present series are now to be discussed.

Of our 55 surgical cases only 23 had a pre-operative tilting table test but 42 were tested post-operatively. No medical cases were investigated in this way.

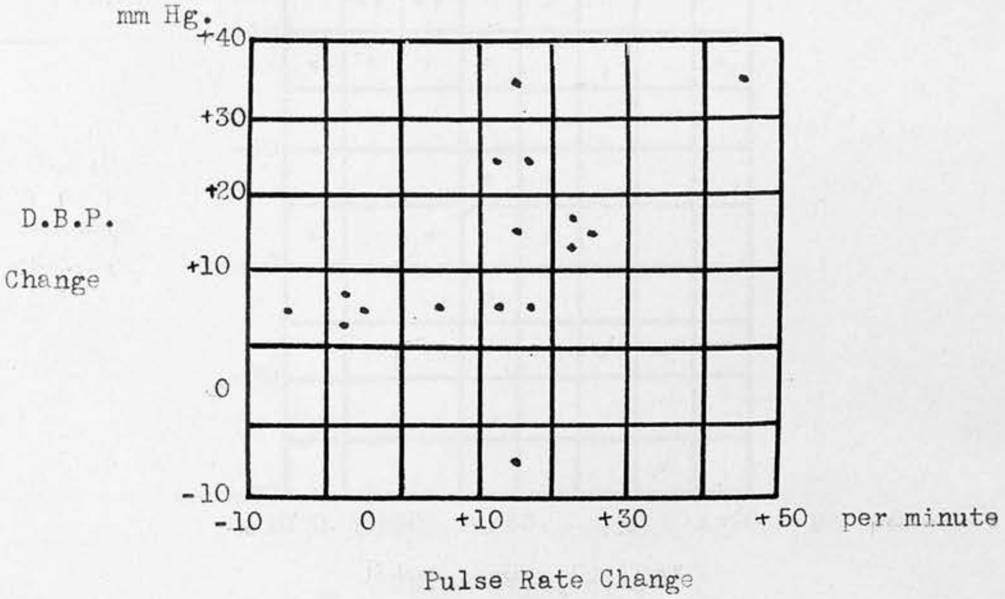
At one or two months after sympathectomy 20 patients were re-tested, not all members of the series of 23 pre-operatively tested.

At 3 to 5 months after operation 12 results are available; at 6 to 24 months, 18 results, and 17 cases were re-tested at periods varying from 2 to 8½ years after operation.

This series of results is set out in Figs. XLIII to XLVII inclusive, the first (Fig. XLIII) being a correlation "grid"/

FIG. XLIII

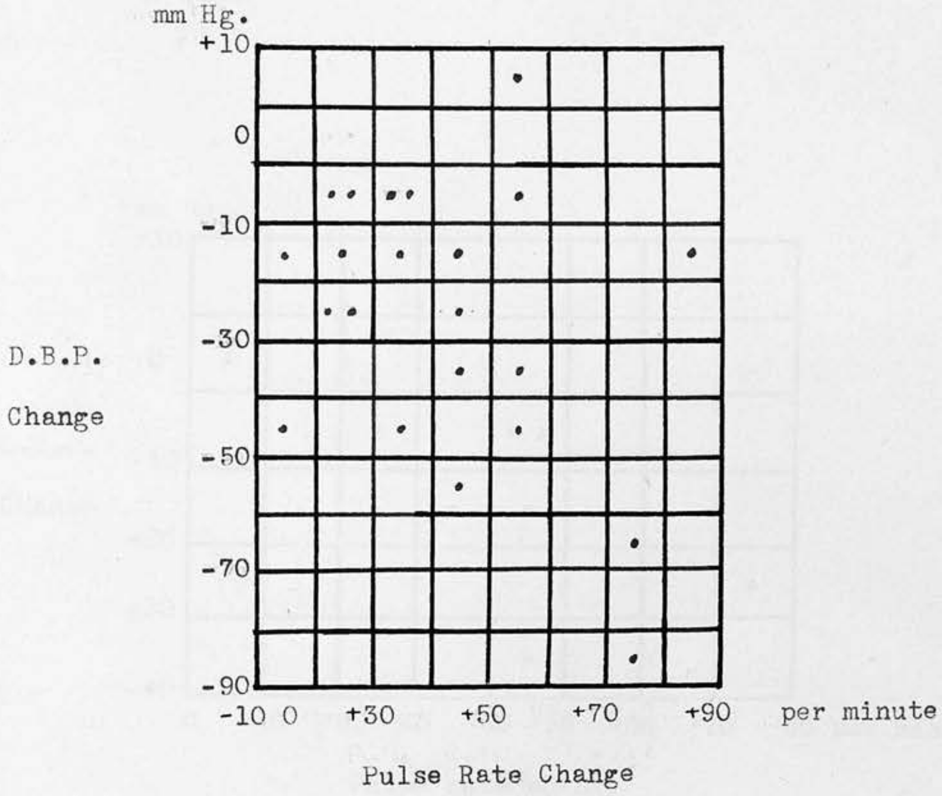
Fig. XLIII: To show the response to tilting head-up in 16 patients prior to sympathectomy. The grid shows the relation of diastolic pressure change to change in pulse-rate.



D.B.Pressure	Range of change:	-5 to 40 mm Hg.
	Mean change:	14 mm Hg.
	Median change:	10 mm Hg.
Pulse Rate	Range of change:	-4 to 44 per minute
	Mean change:	17.6 " "
	Median change:	1.8 " "

FIG. XLIV

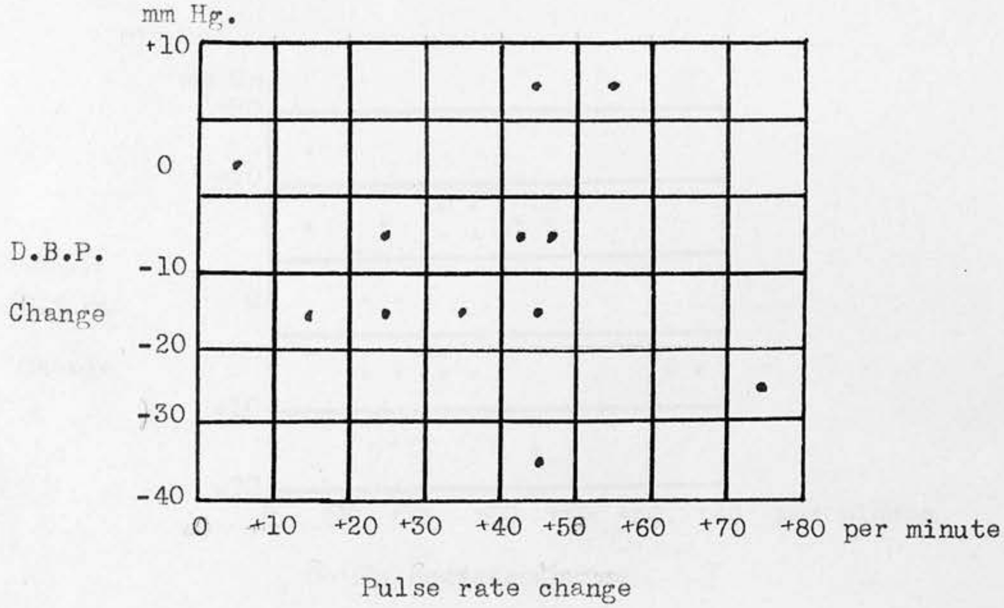
Fig. XLIV: To show the response to tilting head-up in 22 patients one months after sympathectomy. The grid shows the same relationship as in Fig. XLIII.



D.B.Pressure:	(Range of change:	-1 to 90 mm Hg.
	(Mean change:	-27.8 " "
	(Median change:	-22.0 " "
Pulse rate:	(Range of change:	20 to 86 per minute
	(Mean change:	44 " "
	(Median change:	41.5 " "

FIG. XLV

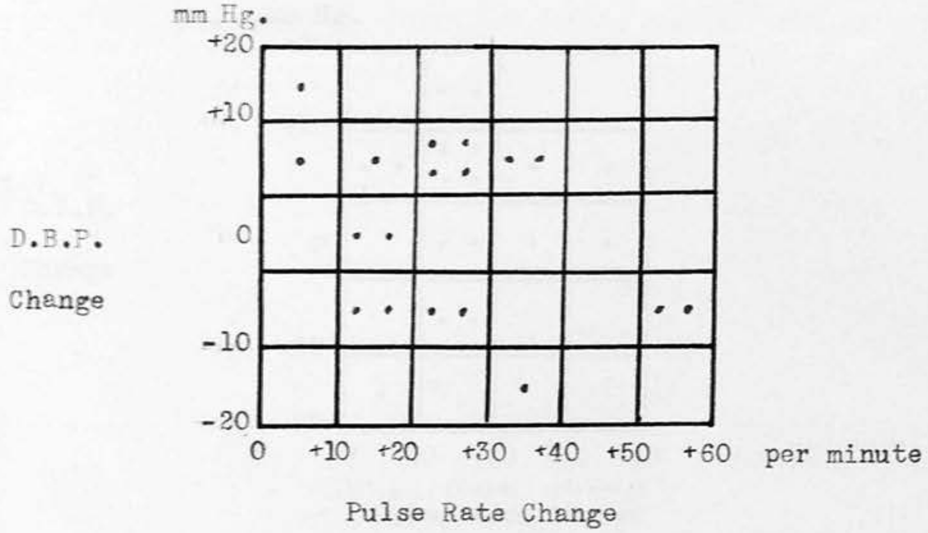
Fig. XLV: To show the response to tilting head-up in 12 patients 3-5 months after sympathectomy. The significance of the grid is as in the previous two figures.



D.B.Pressure:	(Range of change:	6 to -34 mm Hg.
	(Mean change:	-11.2 " "
	(Median change:	-10.0 " "
Pulse Rate:	(Range of change	8 to 80 per minute
	(Mean change:	42.8 " "
	(Median change:	44.0 " "

FIG. XLVI

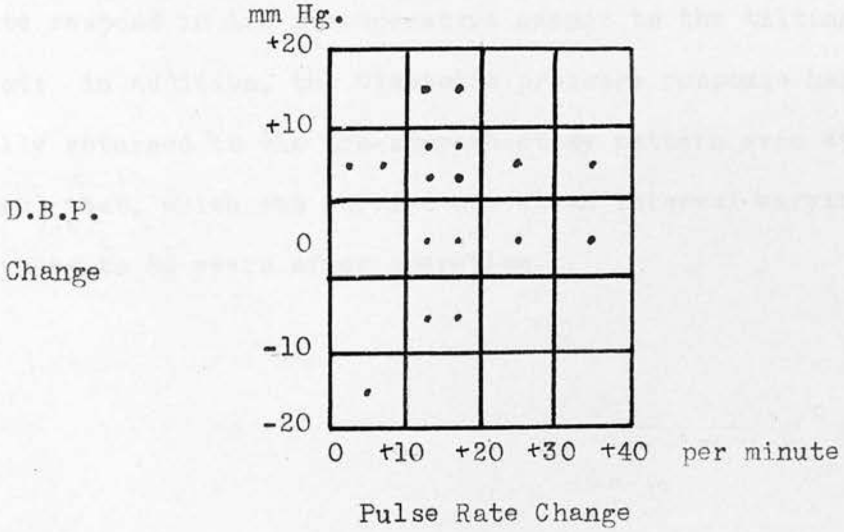
Fig. XLVI: To show the response to tilting head-up in 18 patients 6 to 24 months after sympathectomy. The grid shows the relation of diastolic pressure change to change in pulse rate.



D.B.Pressure:	Range of change:	-14 to 14 mm Hg.
	Mean change:	1 " "
	Median change:	2 " "
Pulse Rate:	Range of change:	4 to 54 per minute
	Mean change:	26.2 " "
	Median change:	27.0 " "

FIG. XLVII

Fig. XLVII: To show the response to tilting head-up in 17 patients over two years after sympathectomy. The grid shows the relation of diastolic pressure change to change inpulse rate.



D.B.Pressure:	Range of change:	-14 to 18 mm Hg.
	Mean Change:	3.1 " "
	Median change:	4.0 " "
Pulse Rate:	Range of change:	4 to 40 per minute
	Mean change:	17 " "
	Median change:	14 " "

"grid" to show the relationship of blood pressure to pulse rate in the normal individual when he is tilted into the erect position; the others show "grids" demonstrating the same fact at various lengths of time after operation.

Putting these results at the pre-operative test and four follow-up periods in tabular form, we have results much as are shown in Table 46.

Putting the facts set out in Table 46 in graphic form we have the result in Fig. XLVIII which shows clearly that only after a minimum of 2 years after sympathectomy does the pulse rate respond in its pre-operative manner to the tilting table test; in addition, the diastolic pressure response has not fully returned to the pre-sympathectomy pattern even at the final test, which was carried out at an interval varying from 2 years to $8\frac{1}{2}$ years after operation.

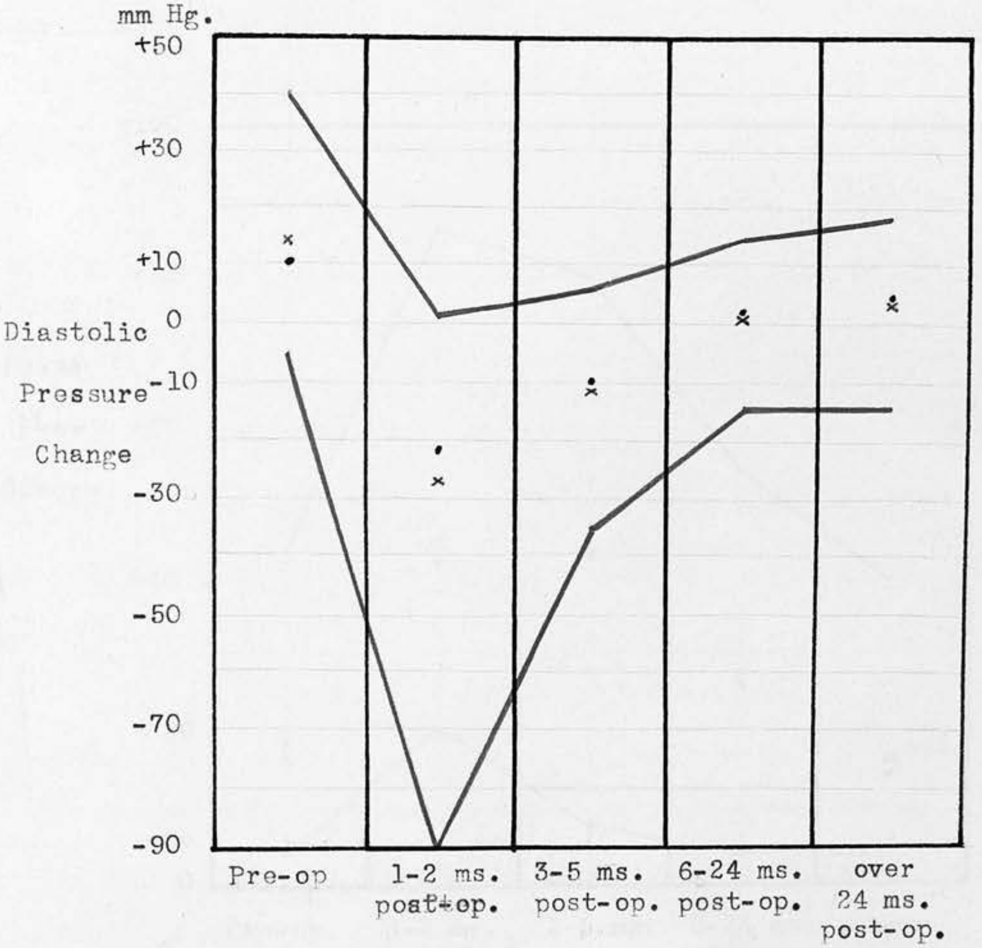
TABLE 46

		D.B.P. change	Pulse rate change
Pre-op. (16 cases)	Range	-5 to 40 mm Hg.	4 to 44 /min.
	Median change	10 " "	18 / min
	Mean "	14 " "	17.6/ min
1-2 months post-op. (22)	Range	-90 to 1 mm Hg.	20 to 26/ min
	Median change	-22 " "	41.5 / min
	Mean "	-27.8 2 "	44.0 / min
3-5 months post-op. (12)	Range	-34 to 6 mm Hg.	28 to 80/ min
	Median change	-10 " "	44.0 / min
	Mean change	-11.2 " "	42.0 / min
6-24 months post-op. (18)	Range	-14 to 14 mm Hg	4 to 54/ min
	Median change	2 " 2	27 / min
	Mean Change	1 " "	26.2/ min
2-8% years post-op. (17)	Range	-14 to 18 mm Hg	4 to 40/ min
	Median change	4 " "	14 / min
	Mean change	3.1 " "	17/ min

Table 46: To show the degree of change in (a) diastolic pressure and (b) pulse rate when the tilting test is carried out pre-operatively and at four successive post-sympathectomy examinations.

FIG. XLVIII (A)

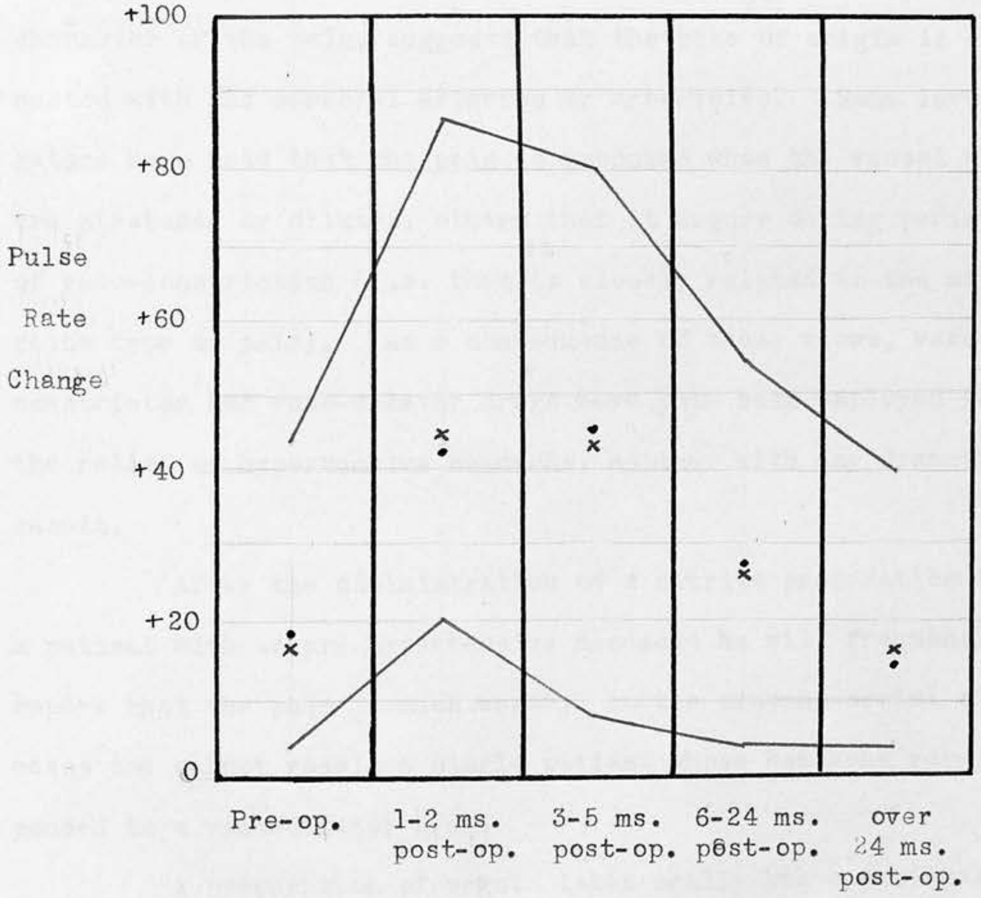
Fig. XLVIII (A): To show graphically the mean and median change as well as the range through which the diastolic pressure varied during tilting, before sympathectomy and at the various intervals after sympathectomy.



Key to Diagram: Red double lines indicate the range } at
Black crosses indicate the mean } each
Black dots indicate the median } period

FIG. XLVIII (B)

Fig. XLVIII (B): To show graphically the mean and median change, and the range through which the pulse rate varied during tilting, before and at various intervals after, sympathectomy.



Key to Diagram: Red double lines indicate the range) at
Black crosses indicate the mean) each
Black dots indicate the median) period

THE PROGNOSTIC SIGNIFICANCE OF
CERTAIN SYMPTOMS IN
HYPERTENSION.

1. Headache.

This symptom is surely that which is most frequently mentioned by hypertensive patients as their major complaint, and its ultimate cause is still uncertain.

The description of a typical hypertensive headache (37) including its early-morning onset in the occipital area, the relief gained when the patient rises, and the "throbbing" character of the pain, suggests that the site of origin is connected with the cerebral arteries or arterioles. Some investigators have held that the pain is produced when the vessel walls are stretched or dilated, others that it occurs during periods of vaso-constriction (i.e. that it is closely related to the migraine type of pain). As a consequence of these views, vaso-constrictor and vaso-dilator drugs have both been employed for the relief of hypertensive headache, neither with any dramatic result.

After the administration of a nitrite preparation to a patient with severe hypertensive headache he will frequently report that the pain is much worse; in the present series of cases one cannot recall a single patient whose headache responded to a vaso-dilator drug.

A preparation of ergot taken orally has occasionally given slight relief, but none of the drugs whose action is specifically/

specifically vaso-constrictor or dilator has given anything like such freedom from pain as the simple Tab. Codeine Co.

With many patients the habit of sleeping with the head of the bed raised on blocks has prevented the occurrence of a severe headache on waking;(5) in other cases, notably plethoric individuals, the regular (3 monthly) attendance at the blood transfusion depot as donors has given striking relief from this symptom.

It is possible that this type of headache is not connected with a state of the blood vessels at any particular time, but that a sensation of pain is produced when the lùmen of the cerebral vessel is constantly altering in diameter, first in one direction, then in the other. It may be an inherent hyper-irritability of those vessels in the individual concerned (such as we have postulated as a cause, when it is generalised throughout the body, of essential diastolic hypertension as a whole) which thus produces frequent changes in the total cerebral arteriolar bed, and it is also possible that such changes could reasonably be held responsible for such a symptom as headache, and for the dizziness which also has a high incidence in the symptom-list of hypertensive patients.

In our series of surgically-treated cases, of the benign hypertensions 73% had headache as a leading symptom. This figure is considerably greater than that given by Bechgaard (8) whose total, out of a series of 1000 cases was only 23.0%

In our series the duration of the history of headaches varied from 1 month to 15 years and the sex distribution was 14 males to 19 females (i.e. 78% of the total benign male cases, and 70% of/

of the total benign female cases).

The percentage of the malignant cases (taken as one unit) is much less - 60% - and it has been our experience that the most troublesome type of headache has not been a main complaint in this group.

The main pre-operative findings in the benign surgical group with headache as their leading symptom are as follows:

A. Duration of symptoms varied from 1 month to 15 years, the average being about 2.5 years in the male cases, and 1.7 years in the females.

B. The age of the males ranged from 21 to 52 years, the mean age being 42.5 years, and the median 44.8 years. For the females the range of age was from 28 to 51 years, mean 39.4, median 38.0 years.

C. As regards the retinal findings, taking the group as a whole, 7 were normal, 14 Grade I, 11 were Grade II and 1 was Grade III.

D. The basic waking diastolic pressures of the group ranged from 80-140 mm Hg., the mean being 115 mm Hg. and the median 119 mm Hg.

E. Cardiac efficiency worked out as follows: 15 were Grade A, 16 Grade B and 2 Grade C.

F. Renal efficiency grades were distributed thus: 19 were Grade A, 14 Grade B.

With regard to the benign medical group with headache

as/

as their main symptom, they numbered 2 males and 15 females, i.e. 31% of the 55 first and second class medical comparisons.

Pre-treatment findings in the *benign medical* cases who complained of *headache* as their leading symptom:

A. *Duration of symptoms* ranged from 3 to 72 months; the mean was 29 months, the median 24 months.

B. The *age*-range was 32-60 years, the mean age was 45.6 years, the median 46.0 years.

C. Their *retinal* grades were as follows: 7 were normal, 4 Grade I, 4 Grade II and 2 Grade III.

D. The *basic waking diastolic pressure* levels were distributed thus: the range was 84 to 134 mm Hg.; the mean was 106.7 mm Hg. and the mean 104 mm Hg.

E. The *cardiac efficiency* grading was: 12 Grade A; 4 Grade B; and 1 Grade C.

F. *Renal efficiency* was as follows: 8 were Grade A, 7 were Grade B, and 1 each for Grades C and D.

Comparing now the two groups, surgical and medical: at the initial examination the surgical group had the more severe symptoms, all without exception being graded C, whereas in the medical series the headaches of 30% were graded B, and 70% C.

The surgical group was slightly younger, had better renal function but about the same retinal grading and cardiac efficiency grading as had the medical series.

Comparing the two "headache-symptom" groups, surgical

and/

and medical, at the 12-months follow-up period, it is of interest to note the progress of each. This is set out in Table 47, from which it is clear that in this group of cases of benign hypertension the surgical series has made greater progress towards general improvement than the medical series has done. This is most marked as regards symptomatic and retinal improvement.

On the whole, therefore, this type of patient, who has a typically purely "hypertensive" symptom as his leading complaint (rather than one suggestive of hypertensive heart disease, or hypertensive renal or cerebral involvement) does better when surgically treated. Without doubt, also, surgery offers a degree of relief from a sometimes intolerable headache with a permanent effectiveness which medical measures have never, in our experience, approached.

The Mortality Rate and Causes of Death in the "Headache-Symptom" Group.

Of the surgical cases, the 26 still alive have been followed for an average of 47.9 months; the 5 who died were observed post-operatively for an average period of 38.6 months.

The causes of death in these 5 cases are set forth in Table 48.

The mortality rate in the 15 medical cases was 2 out of 17; the 15 survivors have been followed up for an average of 34.2 months; the 2 who died were observed for an average of 19.5 months after the start of treatment.

The causes of death in this group were:

TABLE 47

Surgical Cases

	% improved	% no change	% deteriorated
Symptom grade	87.1	19.4	-
Retinal "	29.2	62.5	8.3
Basic D.B. Pressure	69.5	-	30.5
Cardiac efficiency	19.4	64.5	16.1
Renal "	29.6	59.2	11.2

Medical Cases

	% improved	% no change	% deteriorated
Symptom Grade	35.2	53	11.8
Retinal "	8.4	75	16.6
Basic D.B.Pressure	50	-	50
Cardiac efficiency	7.7	84.6	7.7
Renal "	-	93.0	7.0

Table 47: To show the comparative findings at the 12-months follow-up examination of surgical and medical cases who had headache as their presenting symptom.

TABLE 48

Surgical Cases

Case	Sex	Age at operation	Cause of Death	Months observed
1	M	50	Cardiac Failure	19 months
2	F	46	Coronary thrombosis	81 "
3	F	42	Renal failure	40 "
4	F	35	" "	25 "
5	F	36	Cerebral haemorrhage	28 "

Table 48: Details of members of the Group with headache as a leading symptom, who died during the course of the investigation.

Medical Cases

Case	Sex	Age at start of treatment	Cause of Death	Months observed
1	F	45	Renal failure	2
2	F	46	Cerebral haemorrhage	37

Only two of the deaths, one surgical and one medical, are due to a cerebro-vascular cause; the others seem to bear little relation to the presenting symptoms at the time of operation, and there is no bias towards any one type of cause of death.

2. Cerebro-vascular Symptoms (other than headache).

These symptoms come next after headache in order of frequency among those symptoms common in essential hypertension as distinct from hypertensive cardiac of renal disease.

They vary greatly in degree of severity, from minor episodes of cerebro-vascular spasm, lasting a few minutes, to more serious and prolonged attacks of hypertensive encephalopathy, or even to such a major catastrophe as a massive cerebral haemorrhage.

In our investigation 22.2% of the benign surgical and 14.5% of the benign medical cases had cerebro-vascular symptoms as their leading complaint. (The actual numbers of individuals concerned were 10 and 8 respectively.)

Taking both surgical and medical groups together, the pre-treatment findings for this class of patient were as follows:

A./

A. Age: Surgical ages ranged from 19-54 years; the mean age was 38.6, the median 37.0 years.

Medical ages ranged from 20-65 years; the mean was 47.6, the median 48.5 years.

B. Severity of Symptoms: Of the surgical cases, all were Grade C, the most severe grade.

Of the medical cases, 1 was Grade B, 7 were Grade C.

C. Duration of Symptoms: In the surgical series this ranged from 1 day to 30 months; the mean length of history was 9 months, and the median 8 months.

The medical histories ranged in duration from 1 day to 72 months; the mean was 24 months, and the median 42 months.

D. Retinal Grade: Of the surgical group 2 were normal, 5 were Grade I, 2 Grade II and 1 was Grade III.

In the medical series, 1 was normal, 2 were Grade I, 4 were Grade II and 1 Grade III.

E. Basic Waking Diastolic Pressure: This ranged, in the surgical group, from 80 to 140 mm Hg., the mean being 119.0, the median 122.0 mm Hg.

In the medical group the range of levels was 90 to 140, the mean 113.4, and the median 115.5 mm Hg.

F. Cardiac Efficiency: The following grading was found: in the surgical cases 6 were Grade A, 4 Grade B; in the medical cases 4 were Grade A, 4 Grade B.

G. Renal Efficiency: For this factor the following distribution was found to exist:

Surgical cases: 4 Grade A and 6 Grade B.

Medical cases : 2 Grade A, 3 Grade B, 3 Grade C.

From the above details it is seen that the medical cases have longer histories, but less severe symptoms and fall into slightly higher age groups than the surgical patients. With regard to the other factors the performance of the two groups is more or less equal, with the possible exception of the factor of diastolic pressure, in which the surgical group had slightly higher levels.

If the two groups of "cerebro-vascular" patients are compared again on the basis of the findings at the 12-month follow-up examination we find that the results are those set out in Table 49.

The numbers in this series of cases is too small to enable definite conclusions to be drawn from the results shown in this Table.

Surgical cases have shown a more satisfactory fall in waking diastolic pressure after a year and in every factor examined there are more "improved" cases in the surgical than in the medical group. There is not, however the great difference in favour of surgery in relation to symptomatic relief which was found in the "headache-symptom" group of patients.

With reference to the mortality rate in this class of patient, we find that one surgical case died after having been observed for 28 months, while the 9 surviving cases have been followed up for an average length of time of 49.7 months after operation.

In the medical cases, 2 died having been observed for an average of 25 months; the remaining 6 who survived have also/

TABLE 49

At 12-months follow-up

		% improved	% no change	% deteriorated
Symptoms	Surgical	80	20	-
	Medical	62.5	37.5	-
Retinae	Surgical	30	40	30
	Medical	12.5	75	12.5
Cardiac Grade	Surgical	20	60	20
	Medical	12.5	75	12.5
Renal Grade	Surgical	33.3	55.6	11.1
	Medical	12.5	62.5	25.0
D.B. Pressure	Surgical:	Range of change 16 to -40 mm Hg. Mean change -9.3; median change -5 mm Hg.		
	Medical:	Range of change 90 to -25 mm Hg. Mean change 7.6 mm Hg.; median 10 mm Hg.		

Table 49: To show the comparative findings at the 12-months follow-up examination of surgical and medical cases who had cerebro-vascular symptoms as their main initial complaint.

also been followed for an average of 25 months.

The causes of death were as follows:

Case	Surgical or Medical	Sex	Age at initial examination	Cause of death	Months Observed
1	S	F	36	Cerebral haemorrhage	28
2	M	F	48	" "	12
3	M	M	47	" "	38

Although the number of cases is so small, it is probably significant that all the deaths in this symptom-group were due to a cerebro-vascular accident.

On the whole, to summarise the effects of the two types of treatment on this group - surgery does not relieve the patients who have cerebro-vascular symptoms as their main complaint so dramatically as it does those who complain chiefly of headache. It lowers the diastolic pressure to a greater extent than medical treatment does, but it does not appear to protect the individual against a fatal cerebro-vascular accident.

Nor does it protect against minor cerebro-vascular symptoms: two surgical cases, females, who have been followed 67 months and 38 months respectively after sympathectomy have had symptoms of hypertensive encephalopathy occurring at 57 and 24 months respectively after operation. In the former case the attack was transient and cleared up in a few weeks; the latter case has had a succession of minor attacks associated with aphasia and her condition is slowly deteriorating.

In this symptom-group, therefore, neither type of treatment/

treatment offers dramatic results; surgery offers a very slightly better symptomatic and blood pressure improvement but is no protection against a recurrence of the presenting symptom.

~~5~~. Cardiac Symptoms.

Included in these symptoms are "palpitation", dyspnoea and effort pain, the first of these being hardly a "cardiac", but rather a neurogenic or psychogenic manifestation.

10 benign surgical and 14 benign medical patients fall into this symptom-group, their complaints being classified as follows:

	Dyspnoea	Effort Pain	Palpitation	Total
No. of Surgical cases:	6	3	1	10
No. of Medical cases:	7	5	2	14

None of these 24 cases was in cardiac failure when first seen; any case who was in failure at the initial examination was discarded earlier in the proceedings as a "third class medical comparison."

At the initial examination the various findings for this "cardiac symptom" group are as follows:

A. Duration of symptoms: In the surgical series this ranged from 2 to 60 months, the mean being 17.5 months and the median 10 months.
In the medical group the range was from 1 to 120 months, the mean and the median being 39 and 24 months respectively.

B./

B. Severity of Symptoms: All the surgical group were of Grade C, the most severe symptom-grade; of the medical group 71.4% were C and 28.6% B.

C. Age: The surgical patients' ages ranged from 32-54 years; the mean was 44 and the median 45.5 years. In the medical group the range was 41-59, the mean 51.6 and the median 51.0 years.

D. Retinae: In the surgical series 20% were normal, 30% Grade I, 30% Grade II, 20% Grade III.

Of the medical cases, 14.3% were normal, 35.7% Grade I, 42.9% Grade II and 7.1% Grade III

E. Basal Diastolic Pressure: In the surgical group the B.D.P. levels ranged from 90-136 mm Hg.; the mean was 116.1 mm Hg. and the median 119 mm Hg.

In the medical group the range was 90-154, the mean 111.9 and the median 106 mm Hg.

F. Cardiac Efficiency: The surgical cases were graded thus:

A: none; B: 90%; C: 10%

The medical cases were graded thus:

A: 7.1%; B: 42.9%; C: 50%

G. Renal Efficiency: The grading in this factor was as follows:

Surgical cases: 70% A, 20% B and 10% C

Medical cases : 28.6% A, 57.2% B, and 14.2% C

The main points of difference between the surgical and medical "cardiac" patients at this examination are: (1) the age tends to be higher in the medical cases; (2) the diastolic pressure/

diastolic pressures are slightly higher in the surgical group; (3) the medical cases have longer histories; (4) renal function is better in the surgical group.

At the 12-months follow-up examinagion the findings are those seen in Table 50.From the facts there displayed, it is clear that the only two factors which show any obvious difference between surgical and medical results are (1) symptom-grading - where the surgically-treated cases have, as usual, done better than their medical counterparts; and (2) diastolic pressure, in which the surgical group shows a marked drop compared with the medical.

Turning now to the mortality rate in this "cardiac symptom" group of cases we find that no deaths have occurred in the 10 benign surgical cases, who have been followed up for an average period of 33.5 months.

In the medical group of 14 cases, 2 deaths have been noted, both of cardiac failure, at an average period of 26 months after the initial examination. The 12 survivors have been followed up for an average period of 23 months.

Details of the 2 medical cases who died are given below;

Case	Sex	Age at initial examination	Cause of death	Months observed
1	F	53	Cardiac failure	54
2	M	48	" "	4

To summarise: hypertensive patients presenting

cardiac/

TABLE 50

At the 12-months follow-up

		% improved	% no change	% deteriorated
Symptoms	Surgical	100	-	-
	Medical	46.2	38.5	15.3
Retinal Grade	Surgical	12.5	62.5	25.0
	Medical	11.1	77.8	11.1
Cardiac Grade	Surgical	20.0	70.0	10.0
	Medical	46.2	23.2	30.6
Renal Grade	Surgical	30.0	60.0	10.0
	Medical	8.3	66.7	25.0
D.B. Pressure	Surgical:	Range of change: 52 to -23 mm Hg. Mean change -2.6 mm Hg.; median change-9mm Hg.		
	Medical	Range of change: 34 to -14 mm Hg. Mean change 12 mm Hg; median change 10mm Hg.		

Table 50: To show the comparative findings at the 12-months follow-up examination of cases who had cardiac symptoms as their main complaint.

cardiac symptoms as their chief complaint are entitled to the chance of operative treatment and ought not to be debarred from it on account of, e.g. anginal pain, if there is no other major contra-indication (see the concluding section on "Selection for Sympathectomy").

In the small number of cases reported on in the foregoing paragraphs, surgery was more successful than medicine in relieving cardiac symptoms and reducing the diastolic pressure of these patients.

We have now reported on a group of patients with <u>headache</u> as their main symptom, a group complaining of <u>cerebro-vascular</u> symptoms, and a "<u>cardiac</u>" group whose chief symptoms tended to be those of hypertensive heart disease rather than of pure hypertension.

It may be expected now that a similar report will be made on patients with other less common types of leading symptoms e.g. visual deterioration, renal symptoms, tiredness, loss of blood, etc.

In our experience, however, it has been found that those symptoms are relatively seldom mentioned by the mild or moderately severe case of benign essential hypertension. It is when one turns to the consideration of the malignant hypertensive that the whole picture changes, and one finds that such symptoms as have just been mentioned (renal and visual deterioration, weight-loss, exhaustion, blood-loss) leap into prominence.

We therefore intend to present this symptom-complex as a whole, and describe our malignant cases as a group of surgical/

surgical and medical patients with this combination of symptoms as their main complaint. Their initial and post-treatment results will be compared in the same way as has been done with the "headache", "Cerebro-vascular" and "Cardiac" symptom groups.

We therefore present as our final group:

4. The Malignant Hypertension Symptom-complex.

As we have noted in the section on "Material of the Investigation" the malignant group consisted of 19 medical and 10 surgical cases.

Their initial findings were as follows:

A. Duration of Symptoms: Surgical cases had an average duration of symptoms of 10 months, medical cases an average of 20 months.

B. Severity of Symptoms: All the cases in both surgical and medical groups had symptoms of the severest type: Grade C.

C. Age: Surgical ages ranged from 36-61, mean age 45.8, median 45.0 years.

Medical ages ranged from 31-68, the mean being 51.3, the median 50.0 years.

D. Retina: Every case was Grade IV, in both groups.

E. Diastolic Pressure: The surgical levels ranged from 124 to 160, mean 136, median 131 mm Hg.

Medical levels ranged from 96 to 170, mean 138.2, median 140 mm Hg.

F./

F. Cardiac Grade: In the surgical group, 50% were Grade A, 30% Grade B and 20% Grade D.

In the medical group 26.3% were Grade A, 26.3% Grade B, 15.8% Grade C and 31.6% Grade D.

G. Renal Grade: Surgical cases were graded as follows:

None Grade A; 90% Grade B; 10% Grade C.

Medicals were graded: 10.0% Grade C, 90.0% Grade D.

Initially then, the medical cases have a longer duration of symptoms, worse renal function and are on the whole in the higher age-groups. Otherwise there is little difference between the groups.

Before discussing the details of the follow-up examination it is of interest to note the comparative incidence of various symptoms in the two malignant groups, surgical and medical. This is shown in the following list:

Symptom	Surgical Cases	Medical Cases
1. Headache	60%	62%
2. Exhaustion	70%	51%
3. Visual symptoms	40%	62%
4. Blood loss	40%	15%
5. Loss of weight	30%	65%
6. Renal symptoms	10%	55%
7. Cerebro-vascular symptoms	50%	25%

Headache was a common complaint but it was not of the overpowering nature met with in some of the benign cases. In most malignant cases it was overshadowed by a more disturbing symptom e.g. blindness, profuse haematuria or extreme exhaustion, loss/

loss of weight and strength.

At the follow-up examination (which occurred at about 12 months after operation for the surgical cases but was at an average of 2.5 months after the initial examination for the medical cases) the results of surgical and medical treatment was recorded and is set out in Table 51.

The most striking differences between the two results are seen in (1) symptoms and (2) retinal grade where there is no doubt at all that surgery has had the better therapeutic effect.

The most dramatic relief has been experienced probably by those patients who complained of failing vision. One of these, a male aged 44, who had noted sudden deterioration of vision in the 5 weeks before operation, and who by the time he was first seen was almost blind, was able to read on the day following the first half of his sympathectomy. Now, 18 months later, he has no trouble with eyesight, and his retinal grade has improved to Grade III, and almost to Grade II.

The most striking objective benefit of surgery in this group, however, is probably seen in the difference in the mortality rates between surgical and medical cases. This has been dealt with earlier in this report. The causes of death in this group are detailed as follows:

TABLE 51

At the final examination of Malignant Cases

		% improved	% no change	% deteriorated
Symptoms	Surgical	80	20	-
	Medical	-	5	95
Retinae	Surgical	70	30	-
	Medical	-	100	-
Cardiac Grade	Surgical	20	50	30
	Medical	-	52.6	47.4
Renal Grade	Surgical	30	40	30
	Medical	5	90	5
D.B. Pressure	Surgical:	Range of change 30 to -36 mm Hg. Mean change 3 mm Hg; Median change 6mm Hg		
	Medical	Range of change 26 to -38 mm Hg. Mean change -4.6mm Hg; Median change -2mm Hg.		

<u>Table 51:</u> To show the comparative findings at the final examination of the <u>malignant hypertensive</u> cases, i.e. those with the "malignant symptom-complex" as their main complaint.

Mortality in Malignant Group

Case	Type of treatment	Sex	Age at initial examination	Cause of Death	Months observed
1	surgical	M	46	Renal failure	9
2	"	M	61	Carcinoma of liver	10
3	"	M	45	Cardiac and renal failure	5
4	"	F	36	Cerebral haemorrhage	14
5	"	F	45	Cardiac and renal failure	29
1	medical	M	40	Cardiac and renal failure	1
2	"	M	44	Cerebral haemorrhage	2
3	"	M	49	Cardiac and renal failure	5
4	"	M	50	Renal failure	2
5	"	M	66	" "	0.5
6	"	M	54	" "	1
7	"	M	55	" "	0.3
8	"	M	60	" "	6
9	"	M	53	Cardiac and renal failure	1
10	"	M	64	Renal failure	3
11	"	M	53	Cardiac and renal failure	0.5
12	"	M	48	Renal and Cardiac failure	3
13	"	M	48	" " " "	2 days
14	"	F	57	Cerebral haemorrhage	12
15	"	F	31	Cardiac and renal failure	5
16	"	F	48	Renal failure	1
17	"	F	49	" "	1
18	"	F	56	Renal and cardiac failure	2

If we attempt now to summarise this survey of the groups of surgical and medical patients who have had a leading symptom in common, it will be remembered that on the whole the "headache-symptom" group was composed of individuals whose hypertension was of a less severe type, since they belonged to the lower retinal groups, and had more normal grading in the cardiac and renal tests than did the other symptom groups. Their average age was lower than in the other groups; their mean diastolic pressure was roughly the same as the "cerebro-vascular" and higher than the "cardiac" groups.

Surgery had its most dramatic success in this group. In the "cerebro-vascular" series it did not protect against subsequent cerebro-vascular accidents (there were three deaths from cerebral haemorrhage in this group) nor did it, in the "cardiac" patients, protect against subsequent attacks of coronary pain. In the surgical group as a whole there were four post-operative cases of angina of effort, of whom two subsequently developed coronary thrombosis, and in the "cardiac" group there were two deaths of cardiac failure.

The greatest retinal improvement occurred firstly in the malignant surgical group and secondly in the surgical group which complained of headache.

The greatest improvement in the diastolic pressure occurred in the "headache-symptom" group, who had on the average the highest pressures at the initial examination.

For no group, and in no single test, did medical treatment prove superior to surgical. In many they were approximately/

approximately eoual, but, to recapitulate, in the malignant group beyond all doubt, and for the benign group as regards general symptoms and fitness for work, surgery has justified its claim to be recognised as a valuable therapeutic weapon in the attack on essential diastolic hypertension.

COMPLICATIONS AND SEQUELAE
OF LUMBO-DORSAL SYMPATHECTOMY

1. Operative Mortality

In skilled hands this figure is generally of the order of 2% to 3% Smithwick in 1944 (52) had with 378 cases an operation mortality of 3.4%, using the transdiaphragmatic technique. Peet in 1946 after bilateral supradiaphragmatic sympathectomy in 578 cases reported an operative mortality of 3.6% (44).

Smithwick more recently in 1946 (53), after choosing his cases for operation with extreme care, and bringing his operative mortality rate down to nil in a consecutive series of 169 patients, reported a total mortality rate of 2.2% in over 600 patients operated on from 1940 to 1945.

In the present series the operative mortality rate was nil in a series of 55 patients who were not all ideal operative risks from the surgeon's point of view, two of the most severe (malignant) cases suffering also from hypertensive heart failure, and one of these two being obese.

2. Post-operative chest complications

(a) Pleural effusion: this occurred in 15 cases, all of whom had a transdiaphragmatic sympathectomy. Of these 3 had a bilateral effusion, 6 had a right-sided effusion, and 3 of these had associated collapse of the right lower lobe.

6/

(a) Pleural Effusions (cont.)

6 had a left-sided effusion.

These cases all cleared up rapidly and left no permanent effect.

(b) Empyema: There were 2 cases of empyema, of which the bacteriology is unknown. In one of these it was left-sided and associated with collapse of the left-lower lobe; in the other case it was also left-sided but not associated with any pulmonary collapse. Both cases cleared up satisfactorily with penicillin therapy.

(c) Pneumothorax: This occurred in 4 patients, 3 left-sided, one right-sided, and was of a very transient character.

3. Gastro-intestinal Sequelae:

Only 2 of our 55 patients had any major gastro-intestinal complaint after sympathectomy.

One male patient had troublesome and excessively obstinate constipation for 4 to 5 weeks after operation; thereafter he has been perfectly well.

One female case vomited copiously and persistently for 4 days after operation and required intra-venous fluids. The vomiting ceased spontaneously and she remained well thereafter.

The obstinate constipation noted in the first case is an odd result of sympathectomy since the action of the sympathetic nervous system on the intestine (small and large) is that of/

of inhibition, while that of the parasympathetic is the production of increased tone and mobility. Hence it would be expected that when the sympathetic supply was cut off, the parasympathetic would over-act and cause diarrhoea to a greater or less degree. Many of our patients reported that whereas prior to sympathectomy they had been moderately constipated, afterwards they had no trouble whatever, the bowel moving naturally and regularly without aid.

The actions of the sympathetic and parasympathatic fibres on the smooth muscle of the stomach wall are both said to be contraction or inhibition (10) and therefore the intractable vomiting of our second patient must have been due to an excess of the inhibiting action of the parasympathetic system.

4. Symptoms due to Trauma to the Tissues during Operation

(a) Subcostal neuritis, due to the handling of this nerve during operation, was present in every patient in greater or less degree during the early post-operative period; but had normally disappeared in 4 weeks at most.

In 4 cases, however, it persisted for 2 to 3 months and in another 3 cases (all obese women) it lasted over 3 months and has been extremely intractable, difficult to control with simple analgesics, and most exhausting for the patient.

(b) In those three obese cases, but also present in one or two thin individuals, there was a complaint of persistent low backache across the lumbo-sacral area of the spine and both sacro-iliac regions. This was quite distinct from the neuritic pain/

pain described above, which tended to radiate into the groin and occasionally into the thigh.

Measures employed for the relief of pain were, firstly, ordinary simple analgesics such as the B.P. preparation of Tab. Codeine Co. or aspirin. Next, when these failed, pethidine was used with some success, but two cases required morphia while the symptom was at its height.

Subcutaneous wide infiltration of the area on either side of the operation scar with 0.5% Novocaine gave relief for 3 or 4 hours. Short-wave diathermy gave permanent relief to one obese female patient.

In this series it seems that the coincidence of these unpleasant post-operative symptoms with obesity is more than that due to chance; and it is reasonable to suppose that the stouter the patient, the more trauma (even in the most gentle and skilful hands) will be inevitable during the exposure of the site of operation which is not one of the most accessible.

It is therefore worth considering whether sympathectomy for a stout individual should not be postponed until a strict dietetic regime had resulted in a stone or two of weight reduction. This has become our practice during the past year, and we feel that by so doing, a considerable amount of post-operative distress has been avoided.

5. Post-operative Peripheral Vascular Tone in the Upper Limbs

Coldness and blueness of the fingers, hands, nose and ears, in sharp distinction to the warmth and pinkness of the feet and toes, was spontaneously mentioned by 4 of our 55 operated cases after sympathectomy.

The same was admitted, after questioning, by 11 others i.e. 27.3% in all.

Two of these (both females) had swollen blue hands, with chilblains and cracked skin. They had both had a tendency to chilblains prior to operation, but the condition had been intensified since then.

This excessive peripheral vaso-constriction in the upper extremities after sympathectomy may be an attempt on the part of the body to regulate temperature by compensating for vaso-dilatation and heat-loss in the lower half of the body by vaso-constriction and heat-conservation in the upper half.

It is probable, however, that not all the upper part of the body is subject to excessive vaso-constriction. The retinal improvements found after sympathectomy are considered to be due to, or associated with, vaso-dilatation, and it is most likely that the viscera of the upper part of the body, not being concerned in the temperature-regulating mechanism as is e.g. the skin, escape this vaso-constrictor effect.

Further details regarding work done on this phenomenon before and after sympathectomy in hypertensive individuals can be found in papers by Stewart et al. in 1946(56 and 57).

6. Cerebral Sequelae. (i.e. mental capacity.)

Specific questions were put to each patient at the follow-up examination regarding his powers of memory and concentration in the post-operative compared with the pre-operative period. 25% of the patients reported that they were less efficient/

efficient in these respects; 75% noticed no difference.

It is interesting that severe mental illness has occurred post-operatively in 3 of our 55 cases, all females with benign hypertension.

Case 1: Female, aet. 36, emotionally unstable prior to operation, and whose presenting symptoms at that time were psychogenic. Pre-operatively her basic diastolic pressure was 150 mm Hg., retinae normal, and cardiac and renal function also normal.

After operation she remained well for 2 years, diastolic pressure averaging 120 mm Hg. and retinae now Grade I, when she suddenly became acutely psychotic, requiring certification. She has remained in this state for a further 18 months; her cardio-vascular findings are reported to be unchanged.

Case 2: Female, aet. 53, a depressed type of individual prior to operation, suggestive of a case of involutional melancholia, with diastolic pressure of 104 mm Hg., Grade III retinitis and slightly impaired cardiac and renal function. This lady became acutely depressive in the immediate post-operative period and steadily became worse, eventually requiring care and attention in a mental hospital.

Her post-operative findings at a year after operation were: diastolic pressure 118 mm Hg., retinae still Grade III and improvement in cardiac efficiency.

Case 3: Female, aet. 40, who before operation gave no indication whatever of mental instability and held a responsible post/

post in the nursing profession.

Her pre-operative findings included diastolic pressure of 130 mm Hg., retinae Grade I, normal renal function but slightly impaired cardiac efficiency. Her main complaint was of headache.

After operation she did well for 5 years, but during this time the diastolic pressure rose steadily to 164 mm Hg. At this period she became mentally unstable, but moderately well until a year later when paranoiac symptoms and suicidal tendencies developed, and she required certification. Just before she entered a mental hospital her diastolic pressure was 170 mm Hg.; the other findings were unchanged.

She died in the mental hospital 9 months later of coronary thrombosis.

It may be stretching the imagination rather far to draw any conclusions from an incidence of 3 out of 55 cases, but it may be just possible that the altered haemodynamics which follows sympathectomy may be responsible for an abnormal, perhaps diminished cerebral circulation during the hours when the individual is awake and normally in the erect position.

We should now, in view of this experience, consider very carefully before submitting to sympathectomy any individual who is known to have a tendency to nervous or mental instability.

7. Disturbance of Sexual Function

No abnormality was reported by any female patient.

Two/

Two of them became pregnant after sympathectomy, and details of these are now given.

Case 1: Mrs. M.T., aged 23, became pregnant 18 months after operation, her blood pressure during the first few weeks of pregnancy averaging 160/110, i.e. about the same level as during the period since her sympathectomy.

During the 12th to 15th weeks of pregnancy her blood pressure showed a considerable reduction, ranging from 110/70 to 130/80.

During the 20th and 21st weeks it averaged 120/70 with an occasional rise to 160/100 if she were excited.
At the 23rd to 36th week it ranged from 135/90 to 120/80
At the 37th week the readings were 118/80-140/110.
At the 38th week the readings were 140/100-170/104
At the 39th " " " " 170/108-144/100
At the 40th " " " " 164/104-144/104
During the 2 days before delivery the B.P. was 140/104.
On the first day of the puerperium and during the succeeding 8 days it averaged 130/80.

The patient was not seen after her discharge on the 9th day until 18 months later when her pressure was 210/130.

During this pregnancy she had no toxaemic or other symptoms and presented no obstetric problem. Her blood pressure, as happens in the normal pregnant woman, dropped in the middle trimester of pregnancy, reaching low levels even earlier than would be expected. It rose again in the last month, which is later than usual, but during the puerperium again achieved normal levels.

This/

This case is of interest in view of the uncertainty frequently expressed as to whether a sympathectomised hypertensive woman can safely have a pregnancy.

Case 2: Mrs. I.Y., aet. 26.

This patient had a pregnancy 3 years after sympathectomy; it was complicated by eclampsia and resulted in a still-born infant.

During the pregnancy her blood pressure remained high and she had periods of complete loss of vision. Unfortunately details of her pressure, etc., during this time are not available.

This patient had a second pregnancy 5½ years after sympathectomy; she had no symptoms whatever on this occasion and was delivered by Caesarean section of a live healthy baby 3 weeks before term. The puerperium was uneventful and the patient is now, 8¾ years after operation, very well indeed, with, however, a blood pressure averaging 200/130.

In the male as a rule after sympathectomy sexual function is intact in so far as the bilateral operation does not include more than the first lumbar ganglion, and may even be intact if the operation is extended to include the second and third lumbar ganglia.

In all our cases lumbar ganglia 1 and 2 were included and in most cases the third ganglion also, but only one male patient reported difficulty during intercourse.

THE SELECTION OF PATIENTS
FOR SYMPATHECTOMY

We come now to what is one of the most difficult problems confronting physicians and neuro-surgeons at the present time.

From the evidence of a mass of literature on the subject, supported in a very humble way by the results of the present investigation, it must be admitted that lumbo-dorsal sympathectomy is a valuable method of treating essential diastolic hypertension and should therefore be available to all who would benefit by it. But, as we have noted, the operation is time-consuming for both surgeon and patient, the latter not being fit for work for about 6 months, therefore it is not desirable to subject to this major surgical procedure any person who will do equally well with medical treatment.

In the past there has been too much intuitive decision on this matter, and too little careful judgment based on a survey of the patient's performance in the various clinical tests which are thought to have prognostic significance. Most candidates for sympathectomy are, we must admit, submitted to a careful examination of all systems, but too often the results of certain investigations are not given adequate value, while the importance of others is magnified out of all proportion to their actual worth as prognostic tests.

The aim of the final section of this paper, therefore, is to seek for a reliable method of selecting such patients as will benefit by operation - a method which will be as far as possible/

possible objective in character, and independent of the prejudices or preconceived ideas of the physician in charge of the case.

A great deal has been written regarding methods of selection of patients for sympathectomy. In 1940 Allen and Adson (3) refused to operate on patients with congestive cardiac failure, angina pectoris, markedly reduced renal function or severe hypertensive encephalopathy. Smithwick (52) based his selection on the pre-operative resting diastolic blood pressure, the height of the pulse pressure, the retinal grade and the state of the brain, kidneys and heart. He rejects (1) patients in congestive heart failure or renal failure (raised non-protein nitrogen); (2) patients with a basal diastolic pressure of 140 mm Hg. or more, unless there is absolutely no other abnormality of cardiac or renal function and no sign of hypertensive encephalopathy; (3) patients with a diastolic pressure of less than 140 mm Hg. but with a pulse pressure of 20 mm Hg. more than half the diastolic pressure, especially men. Others whom he rejects are patients over the age of 47 with previous cerebrovascular accidents and a poor response to sedation tests; men with diastolic pressures of 120-129 mm Hg., pulse pressures of less than half the diastolic pressure, or half plus 19 mm Hg., age over 37, with abnormal renal function and retinopathy; women with a pulse pressure of half the diastolic pressure, a diastolic level of 120-129, which did not fall to 100 mm Hg., or less, on sedation; and men with a pulse pressure of half the diastolic plus up to 19 mm Hg., a diastolic pressure of 130-139, grade IV retinitis and poor renal function.

Peet and Isberg state more simply, but not necessarily with more truth (44), that any patient, less than 60 years of age, who is not in congestive heart failure, whose blood non-protein nitrogen is below 45 Mg% and who has not sustained a major cerebral accident during the previous months may be considered as a reasonable operative risk.

There are thus many standards, some simple, others endlessly confusing. It is admittedly not justifiable to set the findings of a small series of 55 cases against the results based on series numbering 300, 400, or 1000 cases, but this material is all that is available to us at the moment, and provides some interesting facts and figures.

Criteria of "Improvement"

Before approaching the details of selection let it be quite clear what are our criteria of the "improvement" which is to be aimed at.

It has so frequently been observed that post-operative symptoms do not correlate at all well with post-operative diastolic blood pressure levels, that it has been decided to base our judgment of results on the patients' own subjective symptoms and feeling of fitness for work. This will not be accepted as orthodox by some authorities, and one can find in the works of certain authors no single reference to what the patient himself feels; to us it seems more reasonable to judge success or failure of treatment on the basis of the patient's report of the presence or absence of a feeling of well-being, rather than on abstract measurements and figures.

Patients Rejected for Sympathectomy

Next, let us ask ourselves if there is any type of patient for whom, without further debate, we would recommend medical rather than surgical treatment.

A. One such class of patient is the female at the menopause, whose hypertension may or may not have had its origin at that time. In most of such cases, with or without the aid of oestrogen therapy, the patient will be practically symptom-free in the course of 6 to 12 months, although some individuals may take longer. The blood pressure levels may remain high in spite of symptomatic improvement, but since we have noted earlier that the expectation of life is roughly the same in operated and non-operated benign hypertensives, and that sympathectomy does not by any means always result in a lowering of the blood-pressure, there is no justification for considering surgical treatment for this type of patient. In our series there were 8 menopausal females; 7 of these were symptom-free or had only slight symptoms at the 12-months follow-up examination; the blood pressure levels, however, were normal in only two cases.

B. A second type of case for whom surgical treatment is at once contra-indicated is the patient who has been, or is in cardiac failure. Two of our cases came into this category, one male and one female, both malignant cases. They had both been brought out of failure with digitalis therapy, but neither did well after operation although the issue was complicated in the case of the female by persistent exhausting sub-costal neuritis which was undoubtedly a factor in her gradual deterioration in the post-operative period.

C. Patients with marked renal failure were not accepted by the surgeons for operation, probably justifiably in view of the mass of evidence in the literature in favour of this decision.

D. Patients over the age of 60 with arteriosclerotic perepheral vessels are not on the whole considered good operative risks. There are in fact very few such patients who have not some other definite contra-indication to operation, so that the question does not often arise.

We have not considered,from our experience with such cases that operation is contra-indicated for patients with hypertensive encephalopathy or even frank cerebral haemorrhage; no retinal grade or diastolic blood-pressure figure is per se a contra-indication. Above all, as we shall show, the results of sedation tests are most unreliable guides in this matter and hold a position of great prognostic importance in the eyes of some clinicians - a position which we hope to prove to be totally unwarranted.

Prognostic Value of Preliminary Investigations: Their Correlation with Post-Operative Findings.

It was decided, as the first step in the building up of a new method of selection, to investigate the prognostic significance, for our surgical cases, of the various tests and investigations to which each patient was submitted in the pre-treatment period.

A survey of the preliminary findings having been made, 10 items were selected as having a possible influence on the subsequent progress of the hypertensive patient. These items were/

were the following:

A. Age

B. Duration of Symptoms.

C. Retinal Grade

D. Basic waking diastolic pressure.

E. Basic sleeping diastolic pressure (Amytal test).

F. Cardiac Grade.

G. Heart Size

H. Electrocardiogram.

I. Renal Grade.

J. Degree of Arteriosclerosis.

An attempt was now made to correlate the pre-operative findings in each of these items with (a) the post-operative symptom-grade of the patient, and (b) the post-operative basic diastolic blood-pressure levels.

In order to do this, the items were graded so that a patient's performance in each could be given a "score". The The grades were slightly different from those employed in the tables earlier in this report, and they are described in detail below:

Item A	Age	"Score"
	Under 20 years of age	10 points
	21-30 " " "	8 "
	31-40 " " "	6 "
	41-50 " " "	4 "
	51-60 " " "	2 "
	Over 60 years	0 "

Item B/

Item B Duration of Symptoms

Less than 6 months duration	"Score"	10	points
7 months - 12 months	"	8	"
13 " - 36 "	"	6	"
37 " - 60 "	"	4	"
61 " - 108 "	"	2	"
109 " and over	"	0	"

Item C. Retinal Grade

Normal	"Score"	10	points
Grade I	"	8	"
Grade II	"	5	"
Grade III	"	2	"
Grade IV	"	0	"

Item D. Basic Waking Diastolic Pressure

Minimum D.B.Pressure below 90 mm Hg.	"Score"	10
" " " 90-99 " "	"	8
" " " 100-109 " "	"	5
" " " 110-119 " "	"	2
" " " 120 and over	"	0

Item E. Basic Sleeping ("Amytal") Diastolic Pressure

Minimum Amytal D.B.Pressure below 90 mm Hg.	"Score"	10
" " " " 90-99 " "	"	8
" " " " 100-109 " "	"	5
" " " " 110-119 " "	"	2
" " " " 120 and over	"	0

Item F/

Item F. Cardiac Grade

Normal: (no Symptoms (normal heart	"Score"	10
Slight symptoms on exertion	"	8
Moderate " " "	"	5
Severe " " "	"	2
Symptoms at rest	"	0

Item G. Heart Size

No enlargement		"Score"	10
Slight enlargement	(under 10%)	"	8
Moderate "	(10%- 29%)	"	5
Considerable "	(30% - 49%)	"	2
Gross "	(50% and over)	"	0

Item H. Electrocardiogram

No abnormality	"Score"	10
Slight changes: one or more T waves changes or/ left axis deviation	"	8
Moderate changes: more advanced degree of above	"	5
Severe changes: T wave changes plus marked left axis deviation	"	2
Gross changes: Typical pattern of left ventricular hypertrophy in leads 1,2, and left-sided precordial leads	"	0

Item I. Renal Grade

Very good (range of Urea concentration of 3.0 gm% or more)	"Score"	10
Good (range of 2.0-2.9 gm%)	"	7
Moderate (range of 1.0-1.9 gm%)	"	3
Poor (no range: fixed concentration below 0.9 gm%)	"	0

Item J. Degree of Arteriosclerosis

Radial artery not palpable	"Score"	10
" " barely "	"	8
" "fairly easily palpable	"	5
" " very " "	"	2
" " tortuous and hard	"	0

And the post-operative items thus:

1. Post-operative Symptom Grade

Symptom-free	"Score"	10
Moderate symptoms - fit for work	"	7
Severe symptoms, unfit for work	"	3
Dead	"	0

2. Post-operative Basic Waking Diastolic Pressure

Minimum D.B.Pressure below 90 mm Hg.	"Score"	10
" " " 90-99 " "	"	8
" " " 100-109 " "	"	5
" " " 110-119 " "	"	2
" " " 120 and over	"	0

The next step was to score each of our 55 cases for each of the 10 pre-operative and 2 post-operative items listed above. This done, the ground was cleared for an attempt to correlate each pre-operative test (a) with post-operative symptoms grade, and (b) with post-operative diastolic pressure. It must be noted that in this section of the report we have not used the symptom-grades and diastolic blood-pressures recorded only/

Only at the 12-months follow-up, but have scored the patients for these items at the various post-operative intervals of 6 months, 1 year, 2 years, 3 years and 5 years, and averaged the scores for eachppatient over the whole follow-up period.

The correlations were worked out statistically using the diagonal summation method (16) and the result of correlating each of the 10 pre-operative items (a) with one another, (b) with the total "10-test" score, (c) with post-operative symptoms, and (d) with post-operative basid diastolic pressure is seen in Table 52. (The correlation "grids" from which these figures were derived are shown in the appendix.

From this Table it is to be noted that very few of the 10 pre-operative test items seem to have a positive correlation of any great magnitude with any of the others. The item which correlates best with each of the others, and also best with the total "10-test" score is that of retinal grading.

The best positive correlations found in this Table amongst the pre-operative items are:

(1) FG, i.e. cardiac grade with heart size: 0.58

(2) HI, i.e. electrocardiogram with renal grade: 0.52

(3) DE, i.e. basic waking diastolic pressure, with the basic pressure during Amytal test: 0.51

(4) AJ, i.e. age with arteriosclerosis: 0.49

(5) CH, i.e. retinal grade with electrocardiogram: 0.54

(6) CCI, i.e. retinal grade with renal grade: 0.43

(7) FH, i.e. cardiac grade with electrocardiogram:0.40

If we remove from the above list AJ which is a reasonable and easily understood positive result, also DE, which/

TABLE 52

Intercorrelations of the 10 items with one another, the total "10-test" score, post-operative symptoms, and post-operative diastolic pressure scores.

r	A	B	C	D	E	F	G	H	I	J	"10 tests"	Post-op. sympt.	Post-op. D.B.P.
A	-	0.26	0.38	0.09	0.002	0.02	0.35	0.07	0.33	0.49	0.47	0.29	0.28
B		-	-0.24	0.06	0.02	0.003	0.06	-0.17	-0.45	-0.15	0.10	-0.04	0.05
C			-	0.36	0.39	0.39	0.31	0.54	0.43	0.36	0.76	0.33	0.39
D				-	0.51	0.08	0.00	0.25	0.02	0.14	0.56	0.35	0.41
E					-	0.14	0.22	0.32	0.20	0.06	0.65	0.12	0.50
F						-	0.58	0.40	0.27	0.04	0.49	0.56	0.13
G							-	0.38	0.04	0.23	0.62	0.42	0.26
H								-	0.52	0.28	0.71	0.44	0.27
I									-	0.11	0.50	0.48	0.31
J										-	0.49	0.22	0.4o

"r" signifies the coefficient of correlation which is also a result which would be expected to be positive and fairly high, we are left with correlations which appear to suggest that there may be some factor linking items F, C, H and I, i.e. cardiac grade, retinal grade, electrocardiogram and renal function.

When one examines the relation of each of the 10 items to the total "10-test" score, it is noted that it is item C (the retinal grade) which gives the highest positive correlation of all, followed closely by item H (electrocardiogram findings).

Coming now to the correlation of each pre-operative test with post-operative symptom grade and basic diastolic pressure, it is obvious from Table 52 that very few of the tests give a similar result with both of these post-operative factors; in most cases one is high and the other low. This would suggest that these two factors will have a poor correlation one with the other, and in fact this is the case, the coefficient of correlation being 0.22.

The following Table shows the intercorrelations of the "10-test" score, post-operative symptoms and post-operative diastolic pressure:

	10 test score	Post-operative symptoms	Post-operative D.B.P.
10 test score	-	0.61	0.56
Post-operative symptoms	0.61	-	0.22
Post-operative D.B.P.	0.56	0.22	-

The fact that, although the post-operative symptom-results correlate so poorly with the post-operative diastolic pressures/

pressures, yet the total "10-test" score correlates with each to a fairly high degree (0.61 and 0.56 respectively) suggests that there may be some factor or factors amongst the 10 items which correlate well enough with both to provide a link. The single item which correlates best with both is item I (renal function) with items D and C next in order (waking diastolic pressure and retinal grade).

Taking now those items of which the correlations with each of the post-operative factors are markedly different in magnitude, we find that those which correlate best with post-operative symptoms are items F, G, H and I (i.e. cardiac grade, heart size, electrocardiogram and renal grade) with coefficients of correlation of 0.56, 0.42, 0.44 and 0.48 respectively. Those which correlate best, on the other hand, with post-operative diastolic blood-pressure levels are items C, D, E and J (retinal grade, basic waking diastolic pressure, basic "amytal" diastolic pressure and degree of arteriosclerosis) with correlation coefficients of 0.39, 0.41, 0.50 and 0.40 respectively.

If these eight tests are taken out and placed together as two "batteries", one containing tests F, G, H and I, and the other consisting of tests C, D, E and J, and each battery "score" correlated with the "10-test" score, the post-operative symptoms score and the post-operative diastolic pressure score, results are obtained which are set out in Table 53.

From this correlation table we find that when tests F, G, H and I are placed together, the resulting "battery" score correlates better with post-operative symptoms than did any one of/

TABLE 53

Intercorrelations of "batteried" of pre-operative tests with post-operative symptoms, post-operative diastolic pressure, and the total "10-test" score.

	Battery F,G,H,I	Battery C,D,E,J	10-test score	Post-operative symptoms	Post operative D.B.P.
FGHI	-	0.50	0.78	0.63	0.37
CDEJ		-	0.87	0.35	0.60
10-test score			-	0.61	0.56
Post-operative symptoms					0.22
Post-operative D.B.P.					-

of its constituents when taken separately; similarly the "battery" composed of tests C, D, E and J gives a better correlation with the post-sympathectomy diastolic pressure levels than any of its constituents did when standing alone.

It may be the case that tests C, D, E and J, being connected with the condition of the arterioles, may give a better prognosis than other tests would do of the post-operative state of the arterioles and the resulting diastolic pressure; whereas tests F, G, H and I which are more obviously connected with cardiac efficiency may give a more reliable prognosis regarding subjective symptoms and fitness for work.

The single item which was found to correlate best with both post-operative symptoms and diastolic pressure was, it will be recalled, that of renal grade: let us therefore examine the effect of adding it to the"battery" which does not contain it already, and of subtracting it from the battery in which it already has a place.

The results of this procedure are set out in Table 54.

The addition of item I (renal grade) to the FGH battery (i.e. cardiac grade, heart size and electrocardiogram) has improved its correlation with both post-operative symptoms and diastolic pressure; adding it to battery CDEJ has had less effect, the only significant result being in the correlation with post-operative symptoms.

It may therefore be justifiable to suggest that in any such battery of pre-operative tests or investigations, the factor to which most attention should be paid is that of renal function. In this investigation the factors of age (Item A) and duration

of/

TABLE 54

The effect of adding the factor of Renal Grade(Item I) to the batteries of tests.

	FGH	FGHI	CDEJ	CDEJI
All 10 tests	0.76	0.78	0.87	0.89
Post-operative symptoms	0.57	0.63	0.35	0.42
Post-operative D.B.P.	0.20	0.37	0.60	0.60

of symptoms (item B) have provided poor correlation results and seem to have very little bearing on the post-operative state. In compiling a prognostic series of items for a pre-operative investigation, therefore, it would be justifiable to omit them. The remaining 8 items could then be used as a whole, or the two "batteries" previously described, so as to give some indication as to the probable post-operative grading of the individual according to the criteria of symptoms and diastolic pressure.

Taking these eight tests (i.e. omitting items A and B) and applying them to the benign cases in our series, it is found that almost all those who did not benefit symptomatically by operative treatment had a preliminary total score of less than 60%.

The malignant cases are in an entirely different category here, as in other respects; they all made low total scores on account of their poor retinal grade and severe degree of hypertension, but would not on that account have been debarred from operation. They are a group of which each member is, by the very fact of the extreme severity of the hypertensive condition, an excellent candidate for sympathectomy since we know beyond doubt that the results of surgery are infinitely better than those of medical treatment in these malignant cases.

In summarising our reflections on a method of selection for operation, the following points should be recapitulated:

A. Benign essential diastolic hypertension:

1. The patient's symptoms must be sufficiently severe to warrant a major operative procedure: this refers of course to purely hypertensive vascular symptoms, e.g. headache/

headache, hypertensive encephalopathy, visual deterioration, blood-loss, etc.,(which have not responded to prolonged medical treatment) and not to symptoms of hypertensive cardiac or renal disease which may have become superimposed on the original condition.

2. Although age per se does not correlate well with postoperative symptoms, on general principles no elderly patient (i.e. 60 years or over) would be selected for operation, and if he were arteriosclerotic the contraindication would be all the more definite.

3. No patient who has been or is in cardiac or renal failure is suitable for sympathectomy.

4. No menopausal female patient should be considered for the operation.

5. A benign hypertensive who makes a score of less than 60% on the 8 preliminary tests previously described, and especially on items F, G, H and I (cardiac grade, heart size, electrocardiogram and renal function) should be regarded as unlikely to derive much symptomatic benefit from sympathectomy.

More positively, let us describe the type of case who would probably derive benefit from surgical treatment:

(a) The benign hypertensive case, male or female under 60 years of age, with good cardiac and renal efficiency, retinal grade O to II inclusive, an electrocardiogram of moderate to satisfactory grade, and severe hypertensive symptoms/

symptoms which have not responded to prolonged medical treatment.

(b) The malignant hypertensive case, under 60 years of age, who has not developed severe renal or cardiac failure. (It has already been noted that we should recommend cases of this type with borderline or slightly impaired renal function if the neurosurgeons would accept them.)

(c) The early case of benign hypertension, symptom-free, whose hypertension has been discovered on routine medical examination provides us with a most difficult problem.

If the patient is found to have a consistently high diastolic waking pressure he should be routinely examined at 4 to 6 monthly intervals, special attention being paid to renal function and retinal appearance. The amytal sedation test can play its most useful part in these routine checks - if there is any tendency of the diastolic pressure under amytal sedation to become fixed at a higher level than previously, or if there is a gradual impairment in renal or retinal grading, then sympathectomy should be carried out, since the hypertensive process is obviously progressing. It may well be that a unilateral operation will stop the process for some time, even for years; should it resume activity, or produce severe symptoms the second half can then be carried out.

It will be understood, of course, that these prognostic tests are after all merely pointers, indicating in which direction the hypertensive individual will tend to progress, and too much/

much attention must not be paid to minute detail. This type of work cannot be forced into rigid statistical moulds, and cannot be expected to attach a completely accurate prognosis to each individual pre-operative test score. This attempt, however, to correlate the results of the preliminary tests most commonly employed with the post operative findings may help to put the selection of cases for sympathectomy on a sounder and more objective basis.

Notes on the Prognostic Value of Sedation Tests in Selection for Sympathectomy.

Before leaving the subject of selection for sympathectomy, let us return for a moment to the consideration of the sodium amytal sedation test, hitherto the most commonly employed of such tests and the favourite selective "weapon" of most clinicians (12,49).

As has been noted in the description of this test in an earlier section ("Material of the Investigation") it takes at least 5 to 6 hours to carry out if accurate results are to be obtained; and if, as we believe can be shown, the results in fact have no prognostic significance, the time wasted in this procedure is quite unjustifiable.

We have records of 63 benign hypertensive patients, of whom 36 were medically and 27 surgically treated, and 10 malignant cases all surgically treated, who each had a sodium amytal test as part of his or her initial investigation, and for whom post-operative symptom-grades and diastolic blood pressure levels are known. The follow-up period is 3 years for the benign and 1 year for the malignant cases from the start of treatment.

Their pre-operative basic "amytal" diastolic pressures (i.e. the minimum readings obtained during the tests) are grouped in grades as we have described earlier:

Grade I	D.B.P.	less than 90	mm Hg.
" II	"	90-99	" "
" III	"	100-109	" "
" IV	"	110-119	" "
" V	"	120 mm Hg. and over	

and for each pre-operative "Amytal" grade the percentage of cases is recorded which fell into the various post-operative grades of symptoms and basic waking diastolic pressures. These results are seen in Table 55. Post-operative symptoms are graded as in previous tables as A - symptom-free; B - moderate symptoms but fit for work; C - severe symptoms, unfit for work; D - dead.

Post-operative diastolic pressures are grouped in grades identical with the "Amytal" grades.

In the benign medically-treated group those cases which did best in the Amytal test (i.e. Grade I) are fairly evenly dispersed throughout the post-treatment grades for both symptoms and blood-pressure. For the remaining groups II to IV the post-treatment pressures tend to become higher, as would be expected; the symptom-grading also tends to worsen.

Thus in the medical group the prognostic value of the amytal results is high where post-treatment diastolic pressures are concerned, and fairly high in relation to symptoms though not accurate for any individual case.

In the surgically-treated group we find that the same state of affairs holds good as far as post-operative diastolic pressures are concerned, although to a less extent; but when we examine the post-operative symptom-grading we note at once that there is no correlation at all between this and the pre-operative Amytal results.

In the benign series, therefore, an amytal test may give a fairly reliable indication as to the probable post-

sympathectomy/

TABLE 55

To show the relation between pre-treatment results in the Sodium Amytal test and post-treatment grading in symptoms and diastolic pressure for surgically and medically treated cases. The post-operative period here is the 3-year follow-up.

Benign Cases

Medical

Pre-treatment | Post-treatment

Amytal Group	D.B.P. level (mm Hg.)	No. of cases	Symptoms				D.B.Pressure					
			A	B	C	D	I	II	III	IV	V	NK
I	89	21	29%	33%	33%	5%	15%	15%	15%	25%	15%	-
II	90-99	6	-	33%	17%	50%	-	-	-	25%	50%	25%
III	100-109	6	-	17%	17%	66%	-	-	-	-	100%	-
IV	110-119	3	33.3%	-	33.3%	33.4%	-	-	-	-	100%	-
V	120 and over	0	-	-	-	-	-	-	-	-	-	-

Surgical

Amytal Group	D.B.P. level (mm Hg.)	No. of cases	A	B	C	D	I	II	III	IV	V	NK
I	89	8	50%	37%	13%	-	37%	-	-	-	63%	-
II	90-99	8	37%	25%	25%	13%	-	37%	-	25%	38%	-
III	100-109	6	13%	17%	17%	33%	-	17%	-	17%	66%	-
IV	110-119	1	-	-	100%	-	-	-	-	-	100%	-
V	120 and over	4	75%	-	-	25%	25%	-	-	-	75%	-

Malignant Cases

Surgical

Amytal Group	D.B.P. level (mm Hg.)	No. of cases	A	B	C	D	I	II	III	IV	V	NK
All Grade V	120 and over	10	20%	40%	10%	30%	-	-	-	-	12%	88%

sympathectomy diastolic pressure level, but will give no guidance whatever as to the symptomatic state of the patient. According to whether we base our judgement of success of sympathectomy on subjective improvement or on lowering of the diastolic pressure, so will the amytal test give anprognosis which is, respectively, valueless or fairly accurate.

Since in our judgement the criterion of success should be the patient's own subjective symptoms first, with the blood-pressure figures a long way behind, we feel that the amytal sedation test in benign hypertensive cases is not worth the time spent upon it.

The results in our small series of operated <u>malignant</u> cases bear~~s~~ this out; all the cases were in group V in the amytal test; post-operatively at the 12-months follow-up 20% were symptom-free, 40% had moderate symptoms but were fit for work, 10% had severe symptoms, and 10% had died. With regard to their diastolic pressures, however, 88% were in the worst category (D.B.P. of 120 mm Hg. and over) and 12% in Grade IV. Here again the test is valueless in the prognosis of post-operative symptom-grade, and, all things considered, might well be omitted from our preliminary investigations unless we were also interested in the probable post-operative diastolic pressure of the individual under consideration.

The only other way in which this test can be of use is as we have observed earlier, when it is given repeatedly to any one individual in order to find out whether the diastolic pressure is becoming fixed or is still labile. Should the pressure show signs of ceasing to fall under sedation it is an indication that the hypertensive process is actively progressing.

DISCUSSION AND CONCLUSIONS

1. The Aim of the Investigation.

The aim of the present investigation was, firstly, the evaluation and comparison of the results of medical and surgical treatment on a group of cases of essential diastolic hypertension, all of whom had been assessed by the same workers, the standards of judgement thus being kept more constant than is possible when a surgical series studied at first hand is compared with the medically treated cases of other workers such as the Keith-Wagener material (38, 63) so frequently employed.

Secondly, the aim of our work was to attempt to develop a new scheme on which the selection of patients for surgical treatment could be based.

The term "essential diastolic hypertension" having been defined (pp. 1-4), a description has been given of the medical and surgical measures employed in the treatment of the patients in the present series.(pp. 7-8).

2. The Material.

The next step was to describe our cases and show that, both as one whole group and in smaller matched sub-groups, the medical material was fully comparable with the surgical at the start of treatment.

Of the 151 cases with whom we started the investigation, 96 were medically and 55 surgically-treated. Since this work was/

was not planned in advance, it was necessary to match medical with surgical cases in retrospect.

As we have described (pp. 28-29) this procedure resulted in 11 female and 8 male groups each consisting of surgical cases matched on the basis of retinal examination, and cardiac and renal efficiency, along with medical cases who were as similar to the surgical as possible in those three respects. We have described how the medical cases in each group were graded as first- and second-class comparisons; the remainder of the medical cases in any group (i.e. those who did not fit in well with the group standards) were termed third-class comparisons and were discarded.

The preliminary investigation of both surgical and medical groups has been described in detail both as regards the subjective symptoms of the patients and also as regards objective phenomena such as retinal appearances, basal diastolic pressure, cardiac and renal efficiency and electrocardiogram. The result showed that the medically treated cases tended to be older, which was in their favour, since hypertension on the whole runs a more benign course in the older age-group. The oldest group of all were the medical male cases, the youngest the surgical female cases; if it be true that the hypertensive process tends to be milder in the female as well as in the older patient, then these differences in our series in regard to age and sex cancel one another out.

More medical cases than surgical had a history of less than one year's duration (44% as against 36.8% in the benign hypertensive groups) but by far the most severe symptoms were manifested/

manifested by the surgical series.

No significant difference was noted between the surgical and medical groups in relation to retinal, electrocardiogram, heart size or sedation test gradings; the surgical group had more favourable results in cardiac and renal efficiency tests but were definitely poorer as regards basal waking diastolic pressure.

3. The Method.

Having described the material in detail and demonstrated that the two groups of surgically and medically treated cases were reasonably comparable when taken as wholes and even more strictly comparable when subdivided and dealt with as matched groups, our next step was to evaluate the results of the two forms of treatment.

This was done in two ways:

(a) graphically, showing for the groups as wholes in tabular form the percentages who improved, deteriorated, or remained unchanged under treatment; and

(b) by statistical calculations on the matched groups, to give the final and conclusive verdict regarding any difference between the effects of the two types of treatment on the particular phenomenon under consideration e.g. retina, cardiac grade, etc.

These two methods of comparison were applied to the subjective symptoms of the patient, and to the objective phenomena of basic diastolic pressure, retinal grade, cardiac and renal/

renal grades; the graphic or tabular method was used to show the difference in relation to the additional factors of electrocardiogram and heart size; and the statistical method using the matched groups was used to work out the expectation of life in the two groups being compared.

4. Results.

Turning now to the results obtained by applying the methods just described to our material, we shall take the benign cases of hypertension (i.e. cases with retinal grades 0 to 3 inclusive) and consider them separately, since as we have seen, the malignant cases present problems which must be measured by rather different standards.

Benign Cases:

It was found that there was overwhelming evidence that surgical treatment relieved symptoms to a much greater extent than did medical measures. It will be remembered that the surgical group presented the most severe subjective symptoms in the pre-treatment investigation, yet at the 12-months follow-up examination 40 of the 53 surgical cases who had severe and incapacitating symptoms were back to work (i.e. 75.5%) and 26 (50% of the 53) were symptom-free. Of the medical cases on the other hand only 10.8% were symptom-free after a year and only 40.5% fit for work.

This striking difference in favour of surgical treatment was not always associated with a drop in the basal diastolic pressure/

pressure; as we have seen, post-operative symptoms and post-operative diastolic pressure levels correlated poorly. But, in fact, in relation to the diastolic pressure also, surgery proved more effective than medical measures, producing a significant lowering of the basal diastolic level. The actual changes resulting from the two forms of treatment were small (surgery resulted in an average diastolic fall of 8.4 mm Hg. whilst medical treatment resulted in an average rise of 8.4 mm Hg.) but the difference is statistically significant (see p. 38).

With regard to retinal changes, there was again a difference in favour of surgery which was just significant; this result, however, included the malignant cases who provided the most striking changes; using the benign cases alone there was no significant difference. This finding held good also for changes in cardiac and renal efficiency.

Surgical treatment gave interesting results with respect to changes in the electrocardiogram; of the small number of surgically treated cases who had an electrocardiogram pre- and post-operatively - 22 in all - there was definite improvement noted in 8, i.e. 36.4%. This improvement took the form of reversal of T wave sign from negative to flat or positive, restoration to the iso-electric line of a depressed ST segment and reduction in the left axis deviation. These 8 cases were described in detail and illustrative sections of their electrocardiograms shown.

Of the surgical cases 22% showed a post-operative reduction in heart-size, measured radiologically; only 8.0% of the medical cases showed a similar improvement after treatment.

We/

We have discussed in detail our recommendation not to accept as final any diminution in frontal cardiac area discovered at a period after sympathectomy of less than 6 months, since any earlier result is necessarily associated with abnormalities in postural circulatory dynamics. (p. 66 et seq.). The improvement noted in the surgical cases was mostly a change from Grade B (11% to 30% enlargement) to Grade A (10% enlargement or less).

In relation to mortality rate and expectation of life in the two groups, surgical and medical, it was found that the type of treatment employed made no difference, the actual death rate in each group being five times the expected death rate for persons of like age and sex in the general population, as listed in the Life Table for Scotland for 1931. Other writers (e.g. Hammarström in 1947 (30)) have observed a more favourable expectation of life in cases treated by surgical measures.

We have noted that,,contrary to expectation, the factor of obesity has not operated in our series so as to increase the mortality rate (p. 48), although in life insurance statistics obesity alone gives rise to increased mortality. The relation of obesity to hypertension is not clear but it is significant that whereas these conditions can co-exist in the benign hypertensive individual for years with no apparent ill effect, yet with the onset of the malignant hypertensive phase there is rapid weight-loss along with similarly rapid deterioration in general condition.

Summarising/

Summarising the above findings in the benign cases, we have discovered that surgical treatment has given better results as regards subjective symptoms and fitness for work, and also in the objective phenomena of basal waking diastolic pressure, electrocardiogram pattern, and heart-size. The two methods of treatment have been approximately equal in their effects on retinal grade and cardiac and renal efficiency; and finally there has been no difference between the two groups as regards expectation of life.

Malignant Cases:

Turning now to the smaller group of malignant hypertensive cases, consisting of 10 surgical and 19 medical patients, we shall first of all note a few points in the pre-treatment findings before going on to analyse the results of treatment.

We have noted earlier that on the whole these cases had a shorter history than the benign cases; their symptoms were universally severe and were of a slightly different type from those of the benign cases. The three most typical leading symptoms in this group were exhaustion, loss of weight and visual abnormalities of all degrees. Blood-loss was commoner in this group, usually in the form of haematuria. Headache was common and fairly severe, but was generally over-shadowed by the seriousness of a symptom such as rapidly progressive loss of vision.

Regarding the results of the two forms of treatment in this group, it has been made abundantly clear that, in the first place/

place, medical measures offer practically no relief from symptoms whereas of the 10 cases treated surgically 70% were fit for work a year after operation and 40% were symptom-free.

As regards retinal grade, none of the medical cases improved as a result of treatment whereas 5 of the 10 surgical cases had improved by two retinal grades, and another 2 had improved by one grade.

There was a slight difference in favour of surgery in the renal efficiency grading, but no significant change in cardiac grade, basic diastolic pressure, electrocardiogram or heart-size.

As regards expectation of life the surgical cases have definitely done better as the statistics show (p. 46). For our medical malignant cases the average expectation of life was 2.8 months and all but one were dead in a year. Our longest follow-up for a surgically treated malignant case is 3.5 years, and this individual was still well and fit for work at that time.

Summarising the results for the malignant group, we would maintain that this condition definitely calls for operation if there are no serious contra-indications such as severe renal or cardiac failure. The symptomatic relief in such cases is dramatic, and in view of the great improvement in expectation of life given by surgery we feel it is unquestionably the treatment of choice.

Further Effects of Sympathectomy.

Further Effects of Sympathectomy

1. On the Cold Pressor test results:

When this test is carried out before and after sympathectomy it is found that the maximal diastolic pressure is lower in the post-operative test than in the pre-operative. We suggest therefore that this test gives a reliable indication as to the effectiveness of the operation.

2. On the results of the Tilting Table test: the effect of posture change on blood-pressure and pulse rate.

We have noted the normal and hypertensive types of response to tilting from the horizontal into the head-up position (p.74),and on repeating the test in the post-operative period different results are obtained at different post-operative periods. From our results we estimate that it takes at least 6 months,and on the average from 6 to 24 months after operation, for the blood-pressure and pulse rate to respond again normally to this change in posture.

5. Prognostic Significance of Certain Symptoms.

We have discussed the incidence of,and the type of patient presenting, the three following symptoms, the commonest in the benign group:

A. Headache: This was the leading symptom of 73.3% of the surgical cases and of 30% of the medical group.

After treatment, symptomatic relief was much greater in the surgically treated cases, and in every other factor investigated/

investigated for this group of "headache" cases, surgery gave more favourable results. The mortality rate and causes of death have been noted (p. 82); there were 5 deaths out of 31 surgical cases and 2 deaths out of 15 medical cases. The causes of death were of all types, none predominating.

B. Cerebro-vascular Symptoms: 22.2% of the surgical cases and 14.6% of the medical (all benign) cases complained of symptoms of this type. The medical cases had longer histories but less severe symptoms than the surgical; they were on the whole older than the surgical and had slightly lower diastolic pressures.

Surgery once again gave better results than did medical measures in every objective factor tested for this group (retinal, diastolic pressure, etc.) and also in subjective symptoms, but less dramatically than in the "headache" group.

The mortality rate was 1 out of 10 in the surgical series and 2 out of 8 in the medical: all these individuals, be it noted, died of cerebral haemorrhage.

We have remarked earlier that surgery does not protect the patient against recurrence of minor or even major cerebro-vascular accidents, or against their appearance de novo in a patient who has hitherto been free from such symptoms.

C. Cardiac Symptoms: Of our surgical group 22.2% had such complaints, and of the medical group 25.5%. No case in either group was or had been in cardiac failure.

The age was higher and the history longer in the medical group/

group; in the surgical the diastolic pressure was higher but renal function better.

Surgery improved the diastolic pressure levels and the subjective symptoms to a significantly greater degree than did medical measures; otherwise there was no difference between the groups.

No surgical case in this series died; of the 14 medical cases 2 died of cardiac failure.

Of these three sub-groups of patients with various leading symptoms in common, surgical treatment has again proved the more effective method of the two, chiefly in relieving symptoms: this relief was most marked in the group complaining of headache. Sympathectomy offers no ptotection, however, against subsequent cerebro-vascular accidents, and it must also be remembered that 4 surgically treated cases (not in the "cardiac" group) subsequently developed anginal pain, and of those 4, 2 had an attack of coronary thrombosis.

6. Complications and Sequelae of Sympathectomy.

In the present series there were few serious complications of operation (p.97).

Operative mortality was nil.

Pulmonary complications were as follows:

(a) simple pleural effusion in 27.3%

(b) simple pneumothorax in 7.3%

(c) empyema in 3.6%

All/

All these conditions cleared up rapidly.

Gastro-intestinal sequelae occurred in 3.6% of cases and were troublesome at the time - one was a case of obstinate constipation and the other of persistent vomiting; they are discussed in detail on p. 98.

The incidence of persistent and troublesome sub-costal neuritis was 27.3%; the various remedies employed in its treatment have been mentioned, and the fact of the frequent coincidence of this post-operative complaint with obesity has prompted the suggestion that in a stout patient sympathectomy should be postponed to allow time for dietetic treatment to reduce weight.

We have found no reference in the literature to nervous or mental illness or even mild mental deterioration following sympathectomy, but in this series 25% of cases had noticed deterioration in their powers of memory and concentration, and 5.5% developed serious mental illness. We have discussed these findings (p.101) and theories as to their causation have been put forward for consideration.

Sexual abnormalities have been very few, and have occurred only in male cases (p.103). The two females cases who subsequently had pregnancies are worthy of note since it has sometimes been considered unwise for a sympathectomised hypertensive patient to become pregnant.

7./

7. Selection for Sympathectomy.

This, the final section of our report, is more speculative and theoretical than the preceding sections, but it is hoped that it will provide a basis for more objective judgement and for further research on the subject.

The intercorrelations of the 10 preliminary investigations with one another, with the total 10-test score and with post-operative symptom-grading and basic diastolic pressure (Table 52) have indicated which pre-operative tests are of value in prognosis and which could be done without; the items of "age" and "duration of symptoms" fall into the latter class.

It has also been noted that certain of these preliminary tests, when placed together in a group or "battery" provide a score which correlates well with post-operative symptoms but less well with post-operative diastolic pressure - these are the tests of cardiac grade, heart-size, electrocardiogram and renal function; whereas certain other tests when similarly placed together correlate with the post-operative diastolic pressure figures - these are tests of basic waking diastolic pressure, basic diastolic pressure during amytal sedation, retinal grade and degree of arteriosclerosis.

It has also been found that the test of renal function appears to provide a link between those two batteries; and that this test and the retinal grade are probably the two most important single items in the whole pre-treatment series of investigations.

A note has been added regarding the amytal sedation test/

test: its prognostic value in this series has been found to be small in relation to post-operative symptoms and fitness for work, but it gives a fairly reliable forecast of the probable post-operative diastolic pressure although for any one individual it may be (and has been) quite inaccurate.

Finally, an indication has been given of the types of benign hypertensive case for whom sympathectomy is never indicated - the elderly (over 60 years) and/or arterio-sclerotic, the menopausal female, the patient who has been or is in cardiac failure, or in marked renal failure; a method has been outlined for detailed selection of the benign cases who would probably benefit by sympathectomy; and emphasis has again been laid on the fact that surgery is unquestionably the treatment of choice in the absence of certain contra-indications, for the patient suffering from the otherwise rapidly fatal condition of malignant hypertension.

SUMMARY

An investigation has been described of which the aim has been two-fold:

(a) to compare the result of medical and surgical treatment in two comparable groups of cases of essential diastolic hypertension:

(b) to formulate an improved method of selection of cases for surgical treatment.

We have defined the term "essential diastolic hypertension" and dealt with various theories as to the possible etiology of the condition.

The methods of treatment of the condition, by medical and surgical means, have been described.

The material of the investigation, its character in relation to age, sex, symptoms, duration of history, retinal, cardiac and renal grades and so on, was next described in order to prove that the two groups, medically and surgically treated, were strictly comparable.

The method of arranging the case-material into "matched groups" was next described in order to make clear the manner in which the investigation was converted retrospectively into a carefully controlled experiment.

The/

The results of the two forms of treatment have been reported, showing the difference between the effects of surgical and medical measures on the following items:

(a) subjective symptoms and fitness for work;

(b) objective phenomena, e.g. basic diastolic pressure, retinal appearance, cardiac and renal function, electrocardiogram and heart-size;

(c) the mortality-rate and expectation of life.

The above results were given separately for benign and malignant hypertensive cases, since these two groups were found to present very different problems.

Notes were added as to the effect of lumbo-dorsal sympathectomy on the Cold Pressor and Postural (Tilting Table) tests.

Certain symptoms which were most commonly complained of were then selected for special attention, and the patients whose leading symptoms they were have been collected together and examined as a special group. These symptoms were (a) headache; (b) cerebro-vascular symptoms, (c) cardiac symptoms, and in each group the effects of surgical and medical treatment were noted; the expectation of life, and the causes of any deaths which occurred were also analysed.

The/

The various complications and sequelae of lumbodorsal sympathectomy have been detailed as they occurred in this investigation.

Finally we have dealt with the selection of cases for sympathectomy, and have described an original method of selection based on statistical correlation of the preliminary tests and investigations with post-operative symptom-grades and diastolic blood pressure levels.

Acknowledgements

I should like to express my thanks to Dr. Rae Gilchrist (under whose guidance the work was carried out) for allowing me free access to his cases, and to Professor Norman Dott for permission to follow-up some of his operated cases.

I am especially indebted to Dr. Gilchrist for his continued interest in the work and his unfailing advice and encouragement during the progress of the investigations.

I am also greatful to Dr. Woolf of the Department of Medical Statistics, Edinburgh University, for his help with the statistics in the early part of the thesis.

Lastly I should like to record my appreciation of the courtesy and skill of the technicians in the Departments of Electrocardiography and Radiodiagnosis in the Royal Infirmary, Edinburgh, without which the work would have been much less pleasantly and easily carried out.

BIBLIOGRAPHY

1. ADSON, A.W., CRAIG, W.M., and BROWN, G.E. Surgery in its relation to hypertension.
Surg. Gynec. and Obst. 62: 314, 1936

2. Do. J. Amer. Med. Ass. 102: 115, 1934

3. ALLEN, E.V., and ADSON, A.W. Treatment of hypertension; medical versus surgical.
Ann. Int. Med. 14: 289, 1940

4. ALLEN, E.V., LUNDY, J.S. and ADSON, A.W. Pre-operative prediction of effects on blood pressure of neurosurgical treatment of hypertension.
Proc. Staff Meet. Mayo Clin. 11: 401, 1936

5. ALLEN, E.V. and McLEAN, A.R. The "head-up" bed for hypertensive headache.
Proc. Staff Meet. Mayo Clin. 15: 523, 1940

6. AYMAN, D. Potassium thiocyanate in the treatment of essential hypertension.
J.A.M.A. 96: 1852, 1931

7. BARKER, M.H. Blood thiocyanates in the treatment of essential hypertension with potassium or sodium thiocyanate.
J.A.M.A. 106: 762, 1936

8. BECHGAARD, P. Arterial hypertension: a follow-up study of one thousand hypertonics.
Acta Med. Scand. Suppl. 172, 1946

9. BERWALD, W.P.E. and DEVINE, K.D. Essential hypertension Surgical treatment.
Am. J. Surg. 64: 382, 1944

10. BEST, C.H. and TAYLOR, N.B. The Physiological Basis of Medical Practive. 4th Ed. London 1945.

11. BRUNING, F. Die operative Behandlung der Angina pectoris durch Exstirpation des Halo sympaticus und Bemer Kungen über die operative Behandlung der abnormen Blutdrucksteigerung.
Klin. Wehnschr. 2: 777, 1923

12. CADY, J.B., HORTON, B.T. and ADSON, A.W. Drop in blood pressure produced by sodium amytal, sodium nitrite, amyl nitrite and pentothal sodium: a comparative study.
Bull. Staff Meet. Mayo Clin. 11: 825, 1936

13. CAMERON, J.D.S. The Urea Concentration Range in the diagnosis and prognosis of renal insufficiency.
Proc. Edin. Obstet. and Med. Chir. Soc. 1933-34

14. CANABAL, E.J./

14. CANABAL, E.J., WARNEFORD-THOMSON, H.F., and WHITE, P.D. The electrocardiogram in hypertension III. Electrocardiograms of hypertensive patients followed for a long time without splanchnic resection and comparison with those patients who had had splanchnic resection.
Am. Heart J. 30: 189, 1945

15. CAVINESS, V.S., UMPHLET, T.L., and ROYSTER, C.L. Blood pressure and sulfocyanates.
Am. J. Med. Sc. 204: 688, 1942.

16. CHAMBERS, E.J. "Statistical Calculation."
Cambridge Univ. Press 1943.

17. DANIELOPOLU, D. Chirurgie du systeme vegetatif.
Bull. Med. 37: 988, 1923

18. EVANS, E., PARK, W., MATHEWS, M., and WHITE, P.D.
(a) The electrocardiogram in hypertension I: description.
Am. Heart J. 30: 140, 1945

19. FLAXMAN, N. Treatment of hypertension. Comparison of mortality in Medically and Surgically treated cases.
Ann. Int. Med. 20: 120, 1944

20./

20. GAGER, L.T. The incidence and management of hypertension with a note on thiocyanate therapy.
J.A.M.A. 90: 82, 1928

21. GAMBHILL, E.E., HINES, E.A., and ADSON, A.W. The circulation in man in certain postures before and after extensive sympathectomy for essential hypertension.
Am. Heart J. 27: 360, 1944

22. GARAI, O. Immersion as a factor in the development of hypertension.
Brit. Heart J. 7: 200, 1945

23. GILCHRIST, A.R. The Hypertensions.
Edin. Med. J. 48: 752, 1941

24. GOLDBLATT, H., LYNCH, J., HANZAL, R.F., and SUMMERVILLE,W.W. Studies on Experimental Hypertension I: The production of persistent elevation of Systolic Blood Pressure by means of Renal Ischaemia.
J. Exper. Med. 59: 347, 1934

25. GOLDRING, W. and CHASIS, H. Hypertension and Hypertensive Disease. New York, 1944.

26. GOLDRING, W., and CHASIS, H. Thiocyanate therapy in Hypertension.
(a) Arch. Int. Med. 49: 321, 1932
(b) do. 49: 934, 1932

27. GRIMSON, K.S. Surgical treatment of hypertension.
Surgery 19: 277, 1946

28. GRIMSON, K.S., ALVING, A.S. and ADAMS, W. Total and sub-total sympathectomy in man; effect on blood pressure in hypertension.
Am. J. Physiol. 133: 304, 1941

29. GRIMSON, K.S., WILSON, H., and PHEMISTER, D.B. The early and remote effects of total and partial paravertebral sympathectomy on blood pressure.
Ann. Surg. 106: 801, 1937

30. HAMMARSTRÖM, S. Arterial Hypertension.
1. Variability of blood pressure
2. Neuro-surgical treatment: indications and results.
Acta Med. Scand. Suppl. 192, 1947

31. HARRISON, T.R., GROLLMAN, A., and WILLIAMS, J.R. Renal extracts and hypertension.
Tr. A. Am. Physicians 57: 187, 1942

32. HINES, E.A. and BROWN, G.E. Standard stimulus for measuring vaso-motor reactions: its application in a study of hypertension.
Proc. Staff Meet. Mayo Clin. 7: 332, 1932

33. HINES, E.A. and BROWN, G.E. A standard test for measuring the variability of blood pressure: its significance as an index of the pre-hypertensive state.

Ann. Int. Med. 7: 209, 1933

34. HINES, E.A., and BROWN, G.E. The Cold Pressor test for measuring the reactibility of the blood-pressure: data concerning 571 normal and hypertensive subjects.

Am. Heart J. 11: 1, 1936

35. HOUSSAY, B.A., PASCIOLO, J.C. and TAQUINI, A.C. The role of the kidney in hypertension.

Rev. Argentina D. Cardiologia: 5; 291, 1938

36. HUNTER, A., and ROGERS, O.H. Mortality study of Impaired Lives.

No. 2 Actuarial Soc. Am. Papers and Transac. 24: 378, 1923.

37. JANEWAY, T.C. A Clinical study of hypertensive cardiovascular disease.

Arch. Int. Med. 12: 755, 1913

38. KEITH, N.M., WAGENER, H.P., and BARKER, N.W. Some different types of essential hypertension: their course and prognosis.

Am. J. Med. Sci. 197: 332, 1939

39. PAGE, I.H., and CORCORAN, A.C. Arterial Hypertension.
Its diagnosis and treatment
Chicago, 1945.

40. PAGE, I.H. and HELMER, O.M. A crystalline pressor substance (angiotonin) resulting from the reaction between renin and renin-activator.
J. Exper. Med. 71: 29, 1940

41. PALMER, R.S., SILVER, L.S., and WHITE, P.D. Clinical use of Potassium Thiocyanate in hypertension: a report of 59 cases.
New Engl. J. Med. 201: 709, 1929

42. PEET, M.M. Splanchnic resection for hypertension: a preliminary report
Univ. Hosp. Bull. Ann Arbor, Mich. 1: 17, 1935A

43. PEET, M.M. The surgical treatment of hypertension
J. Int. Chir. V: 1, 1940

44. PEET, MM., and ISBERG, E.M. The surgical treatment of arterial hypertension.
J.A.M.A. 130: 467, 1946

45. PENDE, N. Has adrenaline any physiological value in the organism?
New York M.J. 118: 469, 1923

46. PETERS, J.P., and VAN SLYKE, D.D. Quantitative Clinical Chemistry (Interpretations). 2nd ed. London 1946.

47. ROBINSON, R.W. and O'HARE, J.P. Further experiences with potassium sulfo-cyanate therapy in hypertension.
New Engl. J. Med. 221: 964, 1939

48. ROTH, G.M. The postural effects on blood pressure following interruption of the vaso-motor nerves of man
Am. Heart J. 14: 87, 1937

49. RUSSEK, H.I., SOUTHWORTH, J.L., and ZOHMAN, B.L. The selection of hypertensive patients for sympathectomy
(a) J.A.M.A. 128: 1225, 1945
(b) J.A.M.A. 130: 927, 1946

50. SMITHWICK, R.H. A technique for splanchnic resection for hypertension.
Surgery 7: 1, 1940

51. SMITHWICK, R.H. Surgical treatment of hypertension. The effect of radical (lumbo-dorsal) splanchnicectomy on the hypertensive state of 156 patients followed one to five years.
Arch. Surg. 49: 180, 1944

52. SMITHWICK, R.H. The Surgical treatment of hypertension. Some circumstances under which lumbo-dorsal splanchnicectomy appears to be inadvisable in hypertensive patients.
N.Y. State J.M. 44: 2693, 1944.

53. SMITHWICK, R.H. Experiments with surgical treatment of hypertensive cardiovascular disease in man.

Cleveland Clin. Quart. 12: 105, 1945

Ref. Year Book Gen. Med. 1946

54. SMITHWICK, R.H. Continued Hypertension.

B.M.J. 31st July 1948

55. STARR, I. Inco-ordination of the circulation on standing.

J. Clin. Investig. 22: 813, 1943

56. STEWART, H.J., EVANS, W.F., HASKELL, H.S. and BROWN, H. The perápheral blood flow and rectal and skin temperatures in hypertension.

Am. Heart J. 31: 617, 1946

57. STEWART, H.J., EVANS, W.F., HASKELL, H.S. and BROWN, H. The effect of splanchnic resection on perìpheral blood flow and on skin and rectal temperatures in hypertension.

Am. Heart J. 31: 728, 1946.

58. SYMONDS, B. The Blood Pressure in health.

J.A.M.A. 80: 232, 1923

59. DE TAKATS, G.,GRAUBNER, G., FOWLER, E.F. and JENSIK, R.J.

Surgical approach to hypertension: second report.

Arch. Surg. 53: 111, 1946

60. TIGERSTEDT, R. and BERGMANN, P.G. The effect of renal extract on blood pressure.
Scandinav. Arch. f. Physiol. 8: 223, 1898

61. TRUETA, J., BARCLAY, A.E., BANIEL, P.M. et al.
Studies of the Renal Circulation
(Nuffield Insto. of Med. Research, Oxford 1947)

62. UNGERLEIDER, H.E., and GUBNER, R. Radiological cardiac measurements.
Am. Heart J. 24: 494, 1942

63. WAGENER, H.P., and KEITH, N.M. Diffuse arteriolar disease with hypertension and the associated retinal lesions.
Medicine 18: 317, 1939

64. WALD, M.H., LINDBERG, H.A. and BARKER, M.H.
(a) Toxic manifestations of thiocyanates
J.A.M.A. 112: 1120, 1939
(b) Observations on pathologic effects of thiocyanates
Am. Heart J. 21: 605, 1941

65. WHITE, P.D. Heart Disease. New York, 1946.

66. WHITE, P.D. and SMITHWICK, R.H. The Autonomic Nervous System. 2nd ed.
London 1944.

67. WHITE, P.D., SMITHWICK, R.H., MATHEWS, M.M. and EVANS, E. The electriocardiogram in hypertension II: the effect of radical lumbo-dorsal sympathectomy.
Am. Heart J. 30: 165, 1945

6 8. WILKINS, R.W., HAYNES, F.W. and WEISS, S. The role of the venous system in circulatory collapse induced by sodium nitrite.
J. Clin. Investig. 16: 85, 1937.

Details of Discarded Medical Cases

Males

Case	Group	Age	Details of clinical findings and subsequent course of illness.
1. P.W.	3 B	59	Grossly impaired cardiac and renal efficiency but improved with digitalis and at closure of records had been followed for 11 months and was fit for work.
2. G.W.	3 B	60	Grossly impaired cardiac and renal function. Slight improvement. At closure of records had been followed for 6 months. Unfit to work.
3. H.W.	3 B	64	Considerably impaired cardiac efficiency and slightly impaired renal function. At closure of records had been followed for 41 months and fairly well but unfit for work.
4. J.O'M.	4	50	Grossly impaired cardiac efficiency. Died after 8/12 follow-up: left ventricular cardiac failure.
Females			
1. A.M.	1 B	35	Initial examination matched well but patient developed anorexia nervosa and died in 3/12. P.M. was completely negative.
2. C.P.	1 B	66	Initial examination showed considerably impaired renal function and pt.'s age was higher than the group average. Died in 10/12 of cerebral haemorrhage.
3. M.K.	1 B	27	Grossly impaired renal function but no history suggestive of a renal origin for the hypertension. At closure of records had been followed for 9/12; symptom-free but still with v. poor renal efficiency.
4. E.C.	1 B	28	Initial examination fitted well but subsequently renal function deteriorated and history in childhood suggested unilateral hydronephrosis. Had had renal denervation and splanchnicectomy on 1 side Peptic ulcer and repeated haemorrhage complicated the issue. At closure of records had been followed for 134 months and had only ulcer symptoms, but D.B.P. rising steadily.

Females

Case	Group	Age	Details of clinical findings and subsequent course of illness.
5, M.M.	1 C	56	Had diabetes mellitus assocd. with hypertension. At closure of records had been followed for 23 months and had deteriorated in both renal and cardiac efficiency to Grades C and D respectively. Retina had deteriorated to Gr. III - ?diabetic retinitis.
6. J.McD.	1 C	62	Older than group and had slight renal impairment. Obese . At closure of records had been followed for 56 months and had not deteriorated except retinae now Gr. I. Quite fit for all work.
7. E.O.	2 C.	55	Cardiac and renal efficiency both considerably impaired and had thyrotoxicosis. Followed up for 10/12: slight improvement - had partial thyroidectomy.
8. K.F.	2 C	45	Grossly impaired renal efficiency. Considerably impaired cardiac efficiency. Died after 20/12 of cardiac failure.
9. M.G.	3 B	56	Slightly impaired renal efficiency. In 4/12 had fallen into retinal group IV
10. M.L.	3 B	63	Older than group,and severely arteriosclerotic. Renal impairment. Bundle-branch block. At closure of records had been followed for 48 months and had deteriorated to C in both cardiac and renal function but able to go about.
11. A.J.	3 B	68	Much older than group. Considerable impairment of cardiac and renal function. At closure of records had been followed for 30 months and showed no change.
12. F.D.	3 B	59	Considerably impaired renal function: severe arteriosclerosis. At 29 months she had improved by 1 grade in cardiac function.
13. M.S.	3 B	56	Had associated rh. mitral stenosis, thyrotoxicosis and auricular fibrillation. Died of cardiac failure 4/12 later.
14. J.M.	3 B	52	Impaired renal efficiency. Only followed for 3/12 at closure of records.
15. J.C.	4	45	Associated C. thrombosis - progressed very well but only followed 3/12

Females

Case	Group	Age	Details of clinical findings and subsequent course of illness.
16. M.W.	4	42	Considerably impaired cardiac efficiency. Died 36 months later of cardiac failure.
17. C.M.	4	71	Much older than group and severely arteriosclerotic. Did extremely well: at closure of records had been followed for 15 months and symptoms improved by 2 grades.
18. A.D.	5 B	46	Gross renal failure. Only lived 1 day after first examination.

Table : To show the details of the 22 "medical" patients discarded as unsuitable for comparison with the "surgical" group. They are the third class comparisons mentioned in the text

HEART-SIZE ILLUSTRATIONS

A. Nitrite Experiment: normal subjects

I. A.G. normal male, aet.28

X-rays illustrate the reduction in frontal cardiac area from 150 sq. cm. to 128 sq. cm.; this was associated with a B.P. change from 132/96 to 100/90, and a rise of pulse rate from 96 to 130 per minute.

II. D.H. normal male, aet.26

The frontal cardiac area has been reduced by nitrite from 131 sq. cm. to 117 sq. cm.; this was associated with a change in B.P. from 130/90 to 115/90, and a rise in pulse-rate from 72 to 104 per minute.

B. Sympathectomised hypertensive patients

1. Miss E.A., aet. 46

The post-sympathectomy X-ray was taken at only 4 months after operation and illustrates the similarity of the circulatory haemodynamics at this time to that induced by a nitrite preparation.

The frontal cardiac area is reduced by 20% but there is an associated B.P. change of 210/125 to 160/140 on standing erect, and a rise of pulse rate from 84 to 134 per minute.

2./

B. 2. T.B. Male, aet. 51

This case is also illustrative of the fallacies encountered when taking the post-sympathectomy X-ray in the first 3 or 4 months after operation.

Here there is a reduction in frontal cardiac area of 10% but there is a drop in B.P. from 212/112 to 144/100 on standing erect, and a rise in pulse rate from 64 to 104 per minute.

In the next 3 cases, there was no abnormality of blood pressure or pulse-rate when the patient stood up, the post-operative X-rays being taken at more than 6 months after operation in each case.

3. D.S.L. Male, aet. 35

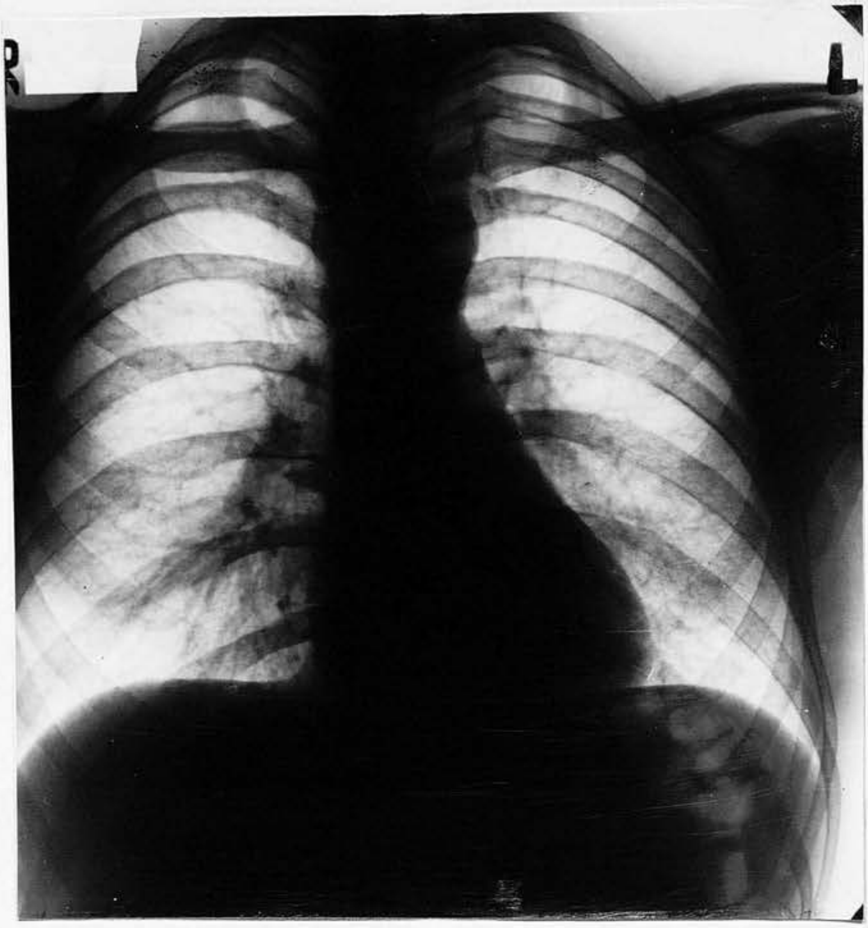
A reduction of 10% in the frontal cardiac area 12 months after sympathectomy.

4. Mrs. J.W., aet. 50

A reduction of 24% in frontal cardiac area 12 months after sympathectomy.

5. D.K. Male, aet.44: a case of malignant hypertension.

Reduction of 15% in frontal cardiac area 8 months after sympathectomy, which has been maintained for a further 10 months.



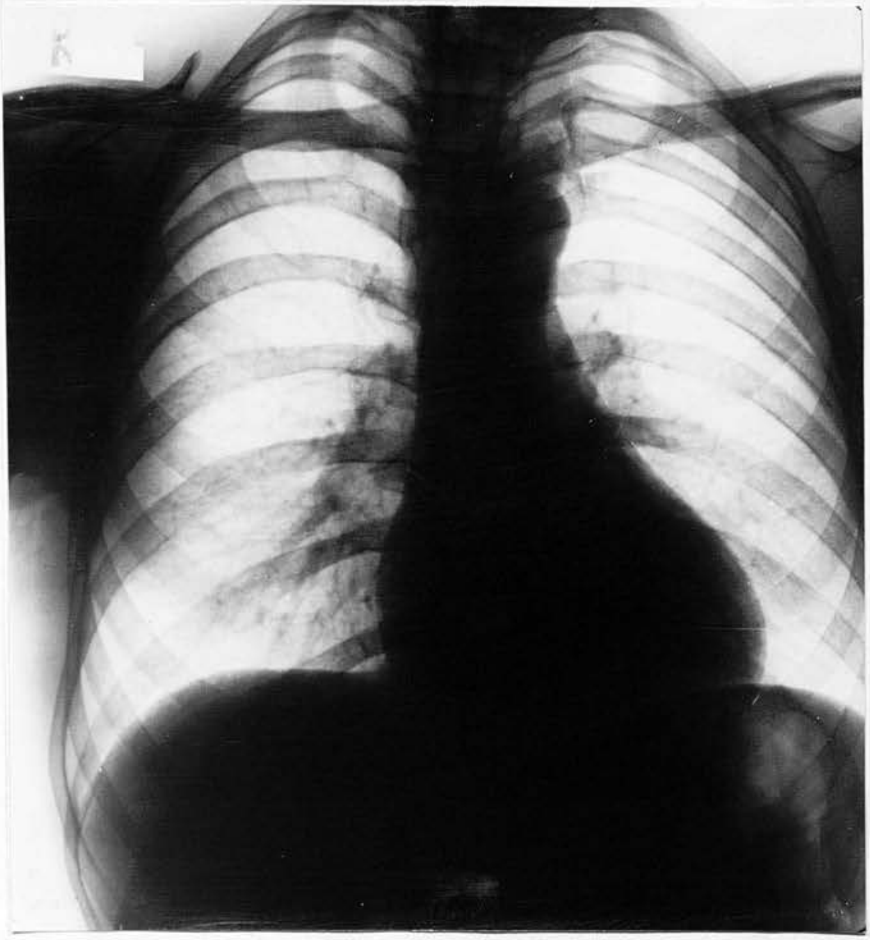
Nitrite Experiment

I

A. G. normal male, aet 28

Post - nitrite Frontal Cardiac Area

128 sq. cm.



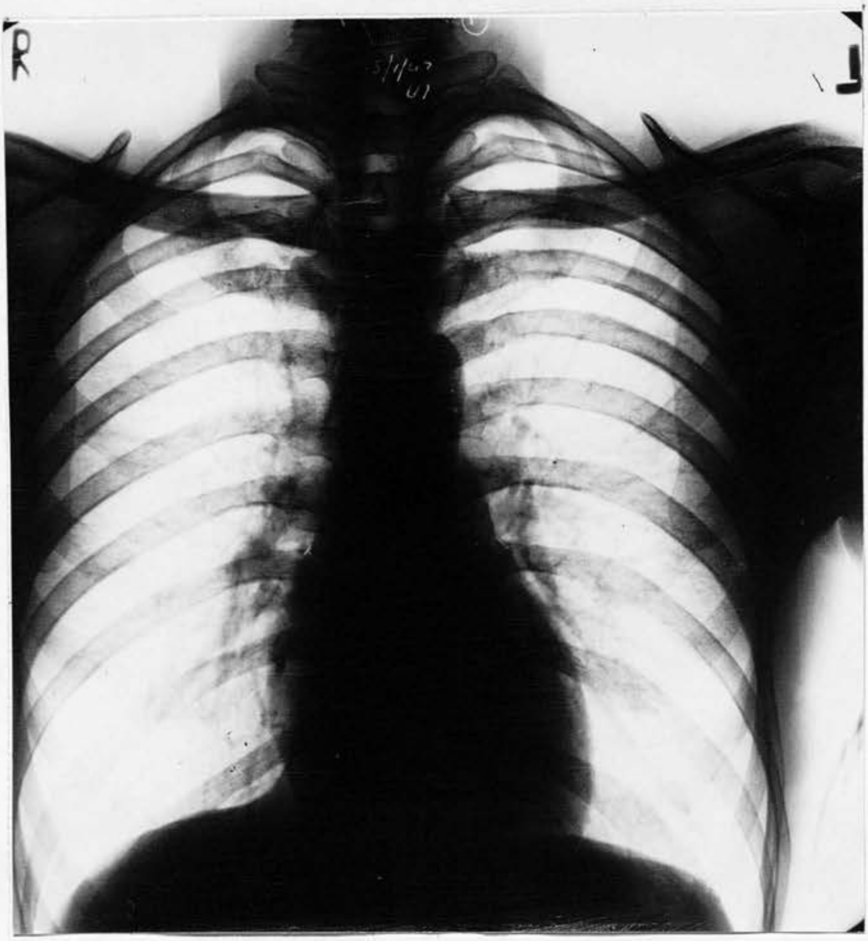
NITRITE EXPERIMENT

I

A. G. normal male aet 28

Pre-nitrite Frontal Cardiac Area

150 sq. cm.



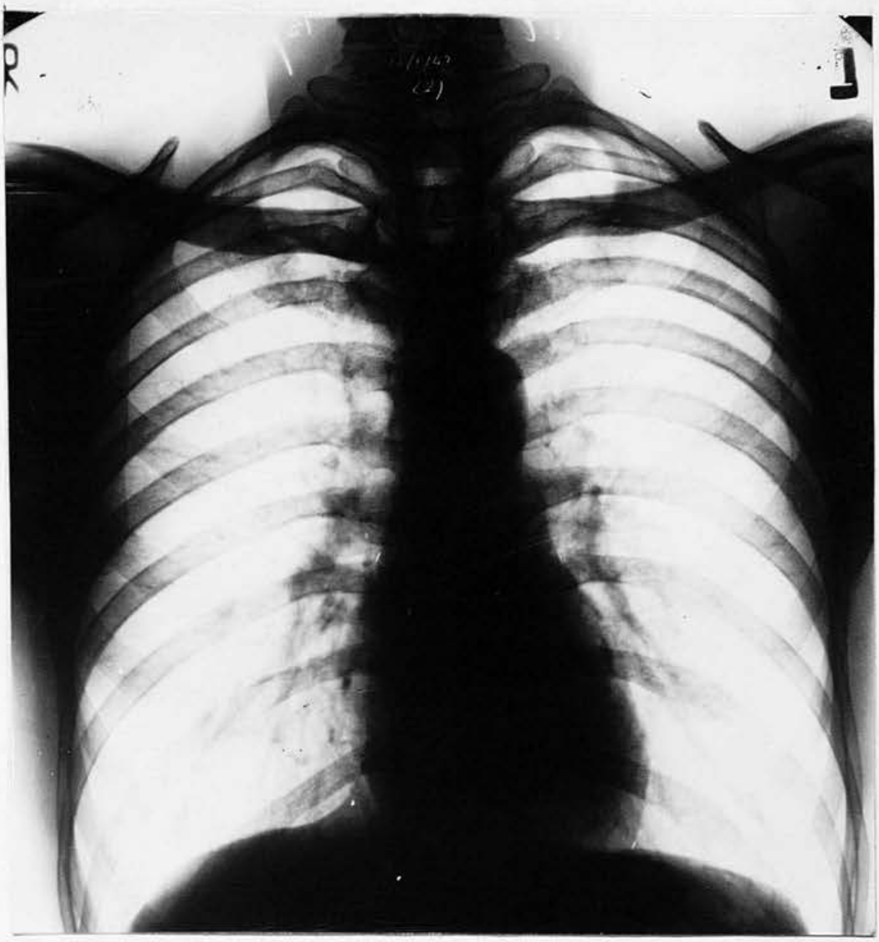
NITRITE EXPERIMENT

II

D.H. normal male aet 26

Pre-nitrite Frontal Cardiac Area

131 sq. cm.



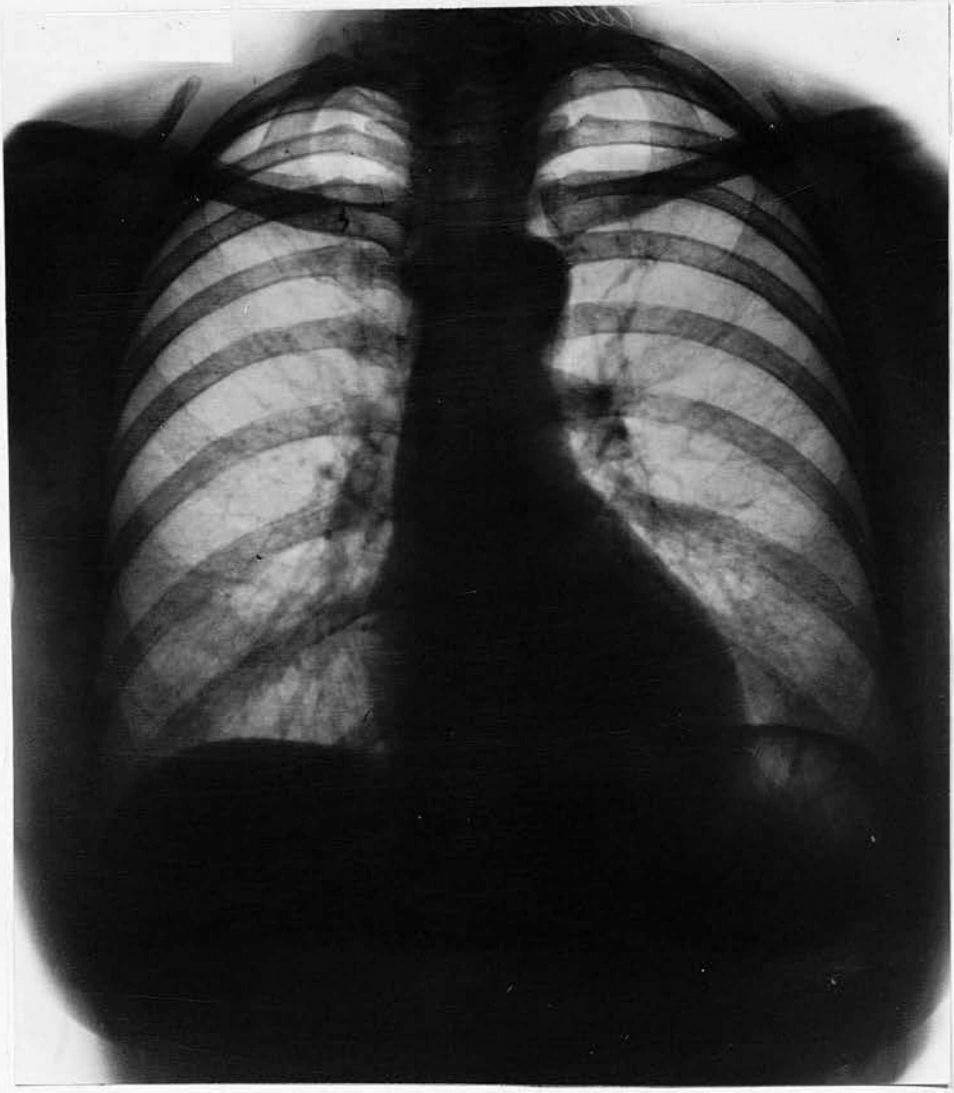
NITRITE EXPERIMENT

II

D.H., normal male aet. 26

Post-nitrite Frontal Cardiac Area

117 sq.cm.

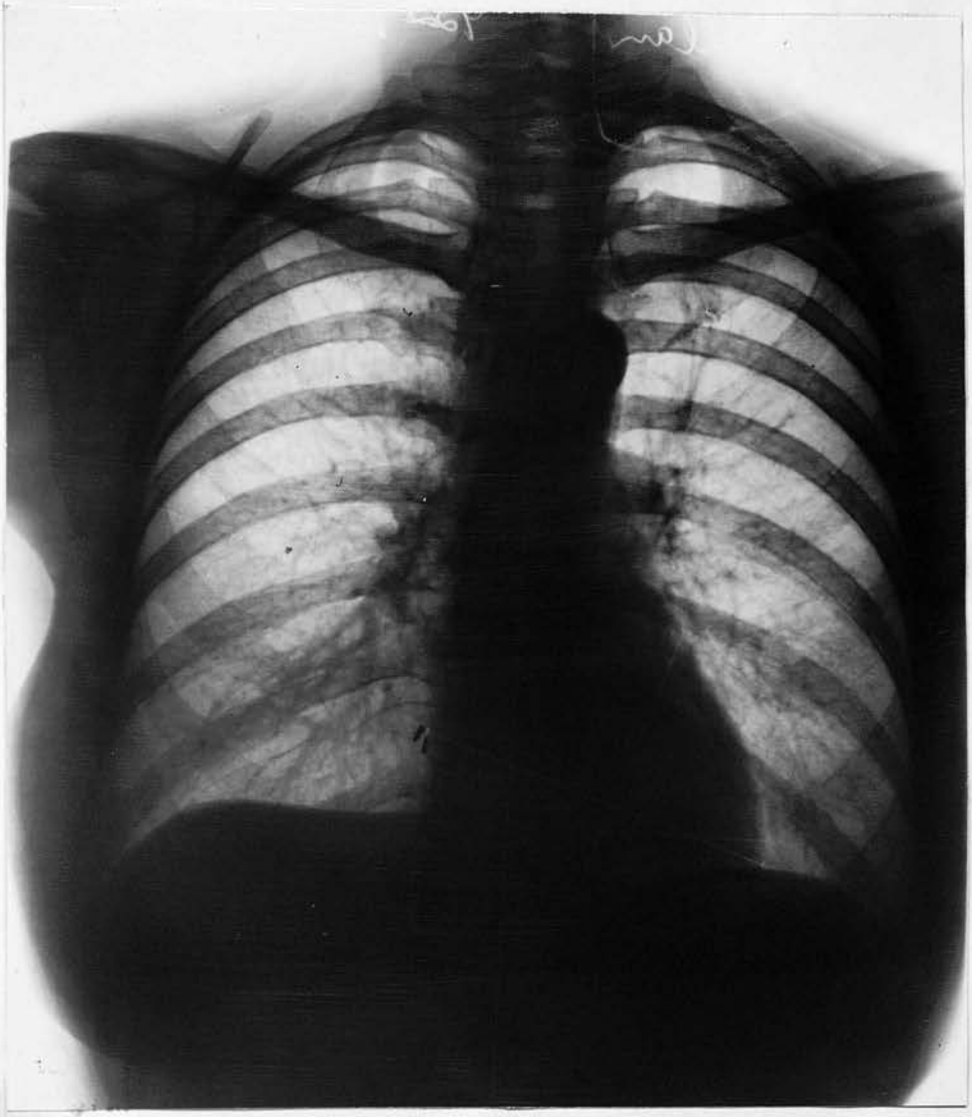


1.

Miss E.A. aet. 46

Pre-sympathectomy Frontal Cardiac Area

No significant enlargement

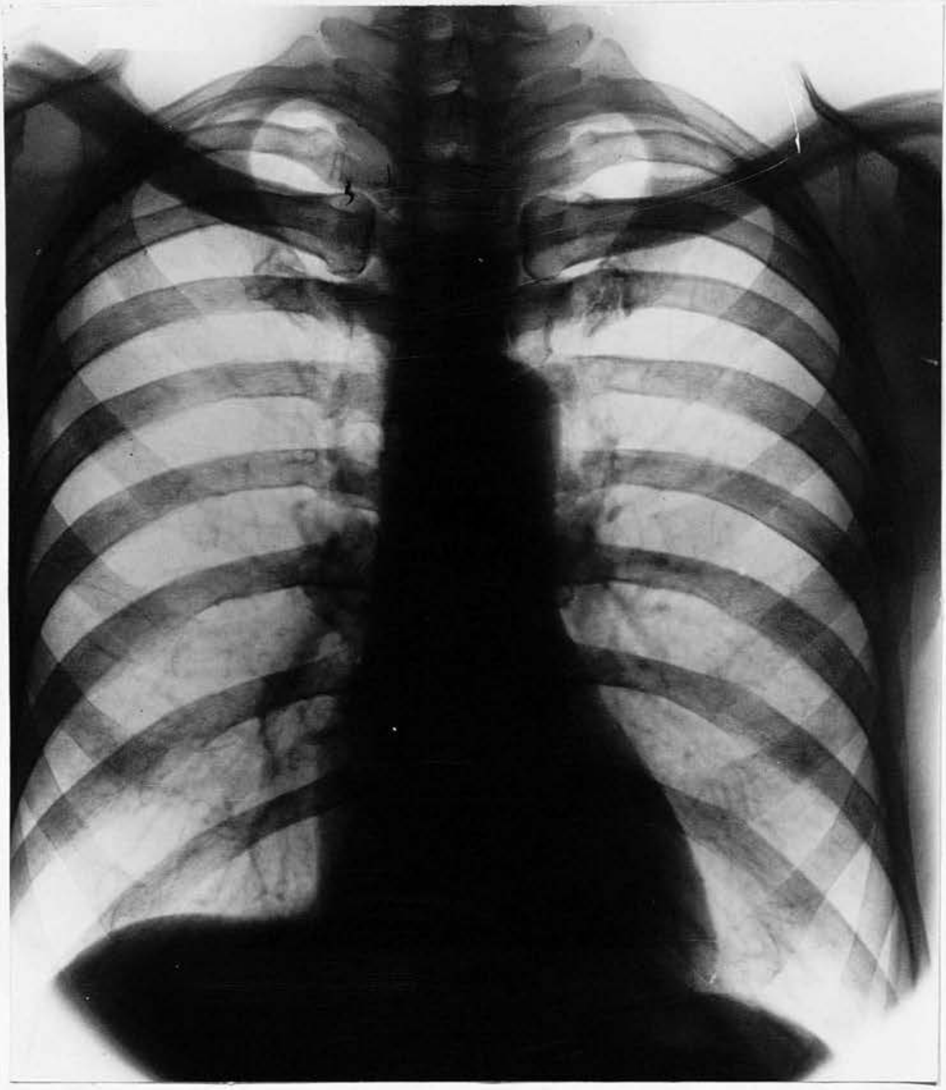


1.

Miss E.A. aet. 46

Post-sympathectomy Frontal Cardiac Area

showing a decrease of 20% 4 months after operation.

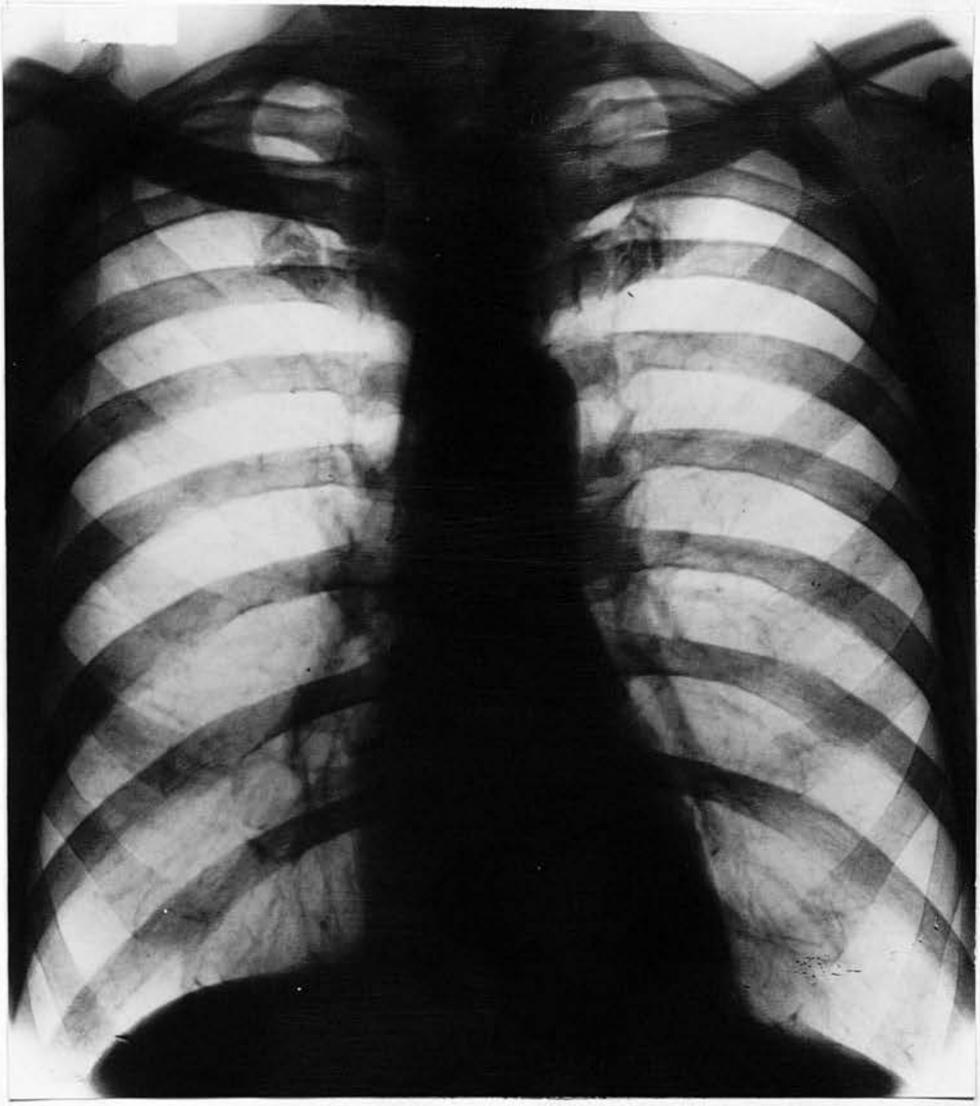


2.

T.B. , Male, aet. 51

Pre- sympathectomy Frontal Cardiac Area

No significant enlargement



2.

T. B., Male, aet 51

Post-sympathectomy Frontal Cardiac Area

showing a decrease of 10% 3 months after operation.

3.

D. S. L., male aet. 35

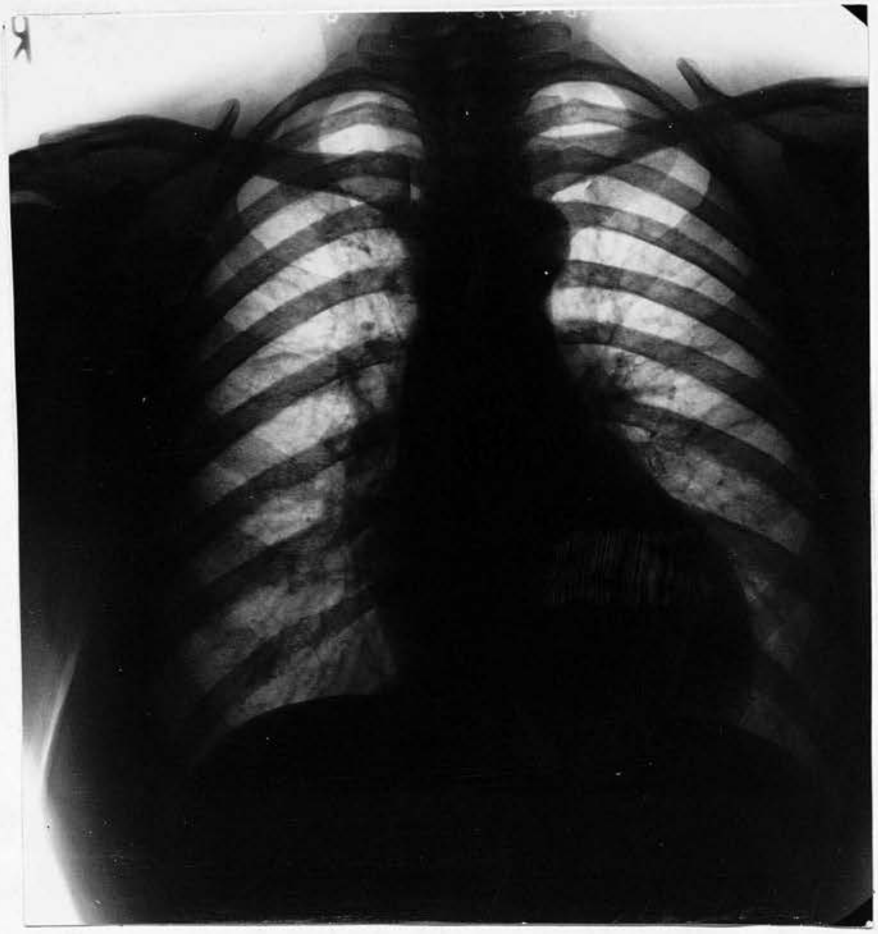
Pre-sympathectomy Frontal Cardiac Area

showing 28% enlargement.

3.

D. S. L., male aet. 35

Post-sympathectomy Frontal Cardiac Area showing 18% enlargement 12 months after operation, i.e. a decrease in size of 10%.

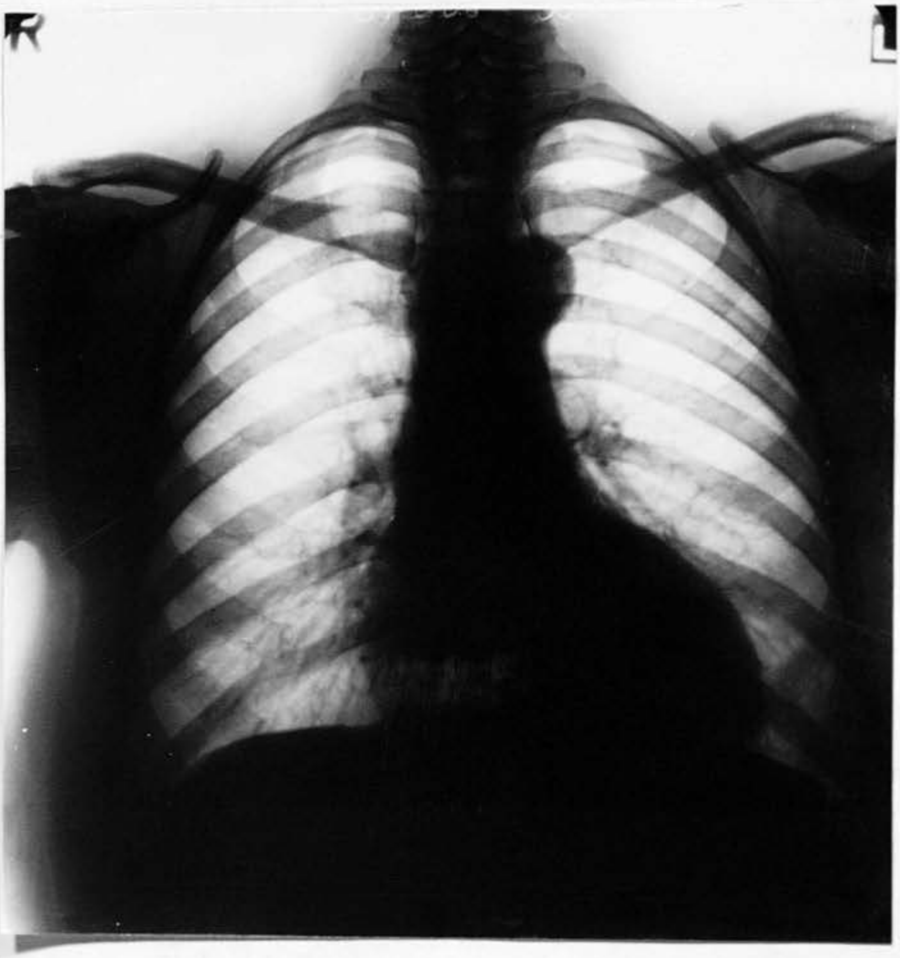


4.

Mrs J. W. aet. 50

Pre-sympathectomy Frontal Cardiac Area

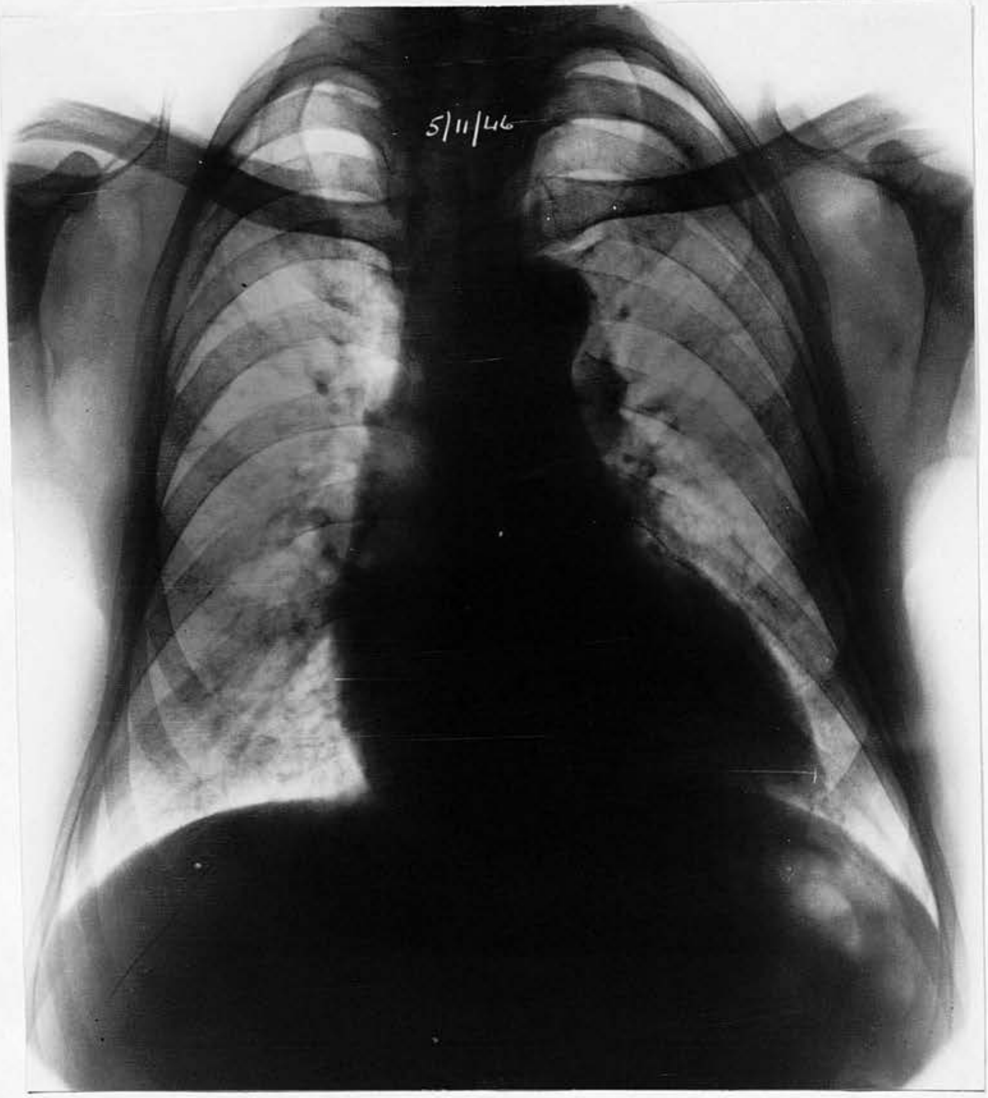
showing 44% enlargement.



4.

Mrs J. W. aet. 50

Post- sympathectomy Frontal Cardiac Area
showing 13 % enlargement 12 months after operation
ie. a decrease in size of 31 %.



5.

D.K., male, aet. 44

Pre-sympathectomy Frontal Cardiac Area

showing 40 % enlargement.

5.

D.K., Male, aet 44

Post - sympathectomy Frontal Cardiac Area
showing 15% enlargement 8 months after operation,
i.e. a decrease in size of 25%.

INTERCORRELATION DIAGRAM (1)

Correlation grids for each of the 10 preliminary tests:

a) with each other

b) with the 10-test score.

c) with the post-operative D.B.P.

d) With the post-operative symptoms.

Red figures denote cases of malignant hypertension

Test A

Test B

Scores	0	2	4	6	8	10	
10		1	1	3	1		5+1
8		1	4+6	3	2	1	11+6
6	1	3	5+1	7			15+2
4		2	2				4
2			1	3+1			4+1
0			1	2			3
	1	7	13+8	18+1	3	1	42+10

Coefficient of correlation : r ≅ 0.26

Test A

Test C

Scores	0	2	4	6	8	10	
10			2	4	3		9
8		4	6	10	1		21
5			7	4		1	12
2		3					3
0	1		8	1			0+10
		7	15+8	18+1	4	1	45+10

Coefficient of Correlation : r = 0. 38

INTERCORRELATION DIAGRAM (2)

Test A

Test D

Scores	0	2	4	6	8	10	
10			2	1			3
8			1	1	1		3
5		2	2	2	3		9
2		2	3	4			9
0	1	3	7+8	10+1		1	21+10
	1	7	15+8	18+1	4	1	45+10

Coefficient of Correlation : r = 0.09

Test A

Test E

Scores	0	2	4	6	8	10	
10		5	3	6	1		15
8		1	2+1	3	1		7+1
5			3	4			7
2	1	1	2+2	2			5+3
0			2+4	3+1			5+5
	1	7	12+7	18+1	2		39+9

Coefficient of Correlation : r = 0.002

Test A

Test F

Scores	0	2	4	6	8	10	
10		2	6	2	4		14
8	1	1	5+4	6			12+5
5		3	4+2	10+1		1	18+3
2		1					1
0			2				0+2
		7	15+	18+	4	1	45+10

Coefficient of Correlation : r = 0.02

INTERCORRELATION DIAGRAM (3)

Test A

Test G.

Scores	0	2	4	6	8	10	
10		2	6	4	3		15
8		1	3+4	6+1		1	11+5
5		3	5+3	7			15+3
2		1	1	1			3
0	1		1				0+2
	1	7	15+8	18+1	3	1	44+10

Coefficient of Correlation : r = 0.35

Test A

Test H

Scores	0	2	4	6	8	10	
10	·	1	1		1		3
8		3	10	7	1	1	22
5	1	1	1+2	8			10+3
2		1	1	1			1+2
0			3	1			1+3
		6	12+	16+	2	1	37+8

Coefficient of Correlation : r = 0.07

Test A

Test I

Scores	0	2	4	6	8	10	
10		1	8+1	10	1	1	21+1
7	1	6	6+3	7+1	3		22+5
3			1+2	1			2+2
0			2				0+2
							45+10
		7	15+8	18+1	4	1	

Coefficient of Correlation : r = 0.33

INTERCORRELATION DIAGRAM (4)

Test B

	Scores	0	2	4	6	8	10	
	10	3			2	2	1	8
	8		2	2	5	7	4	20
Test C	5		2	1	6	2		11
	2			1	2			3
	0		1		2	6	1	0+10
		3	4+1	4	15+2	11+6	5+1	42+10

Coefficient of Correlation : r = -0.24

Test B

	Scores	0	2	4	6	8	10	
	10		1			1		2
	8				1	2		3
Test D	5				2	3	3	8
	2	1	1	1	4	2		9
	0	2	2+1	3	8+2	3+6	2+1	20+10
		3	4+1	4	15+2	11+6	5+1	42+10

Coefficient of Correlation : r = 0.06

Test B

	Scores	0	2	4	6	8	10	
	10		2	2	4	4	3	15
	8	1		1	3	2+1		7+1
Test E	5	1	1		3		1	6
	2		1		3+1	1+1	1	5+3
	0	1	1		2+1	1+3	1	5+5
		3	4+1	3	15+2	8+5	5+1	38+9

Coefficient of Correlation : r = 0.02

INTERCORRELATION DIAGRAM (5)

Test B

Test F

Scores	0	2	4	6	8	10	
10			2	3	6	2	13
8	2	2		3+2	1+2	2+1	10+5
5	1	2+1	2	8	4+2	1	18+
2				1			1
0					2		0+2
	3	4+1	4	15+2	11+6	5+1	42+10

Coefficient of Correlation : r = -0.003

Test B

Test G.

Scores	0	2	4	6	8	10	
10			2	4	7	2	15
8	2	1+1	1	2	3+3	1+1	10+5
5	1	3	1	6+1	1+2	2	14+3
2				3			3
0				1	1		0+2
	3	4+	4	15+	11+	5+	42+10

Coefficient of Correlation : r = 0.06

Test B

Test H

Scores	0	2	4	6	8	10	
10			1	1		1	3
8	2	2	2	6	7	1	20
5	1	1	1	5+1	1+2	1	10+3
2		1		1	1		1+2
0				1	1	1+1	1+3
	3	3+1	4	13+2	8+4	4+1	35+8

Coefficient of Correlation : r = -0.17

INTERCORRELATION DIAGRAM (6)

Test B

Test I

Scores	0	2	4	6	8	10	
10	2	3	3	5	4+1	2	19+1
7	1	1+1	1	9+1	7+2	2+1	21+5
3				1+1	1	1	2+2
0					2		0+2
	3	4+1	4	15+2	11+6	5+1	42+10

Coefficient of Correlation : r = -0.45

Test B

Test J

Scores	0	2	4	6	8	10	
10	2	2+1	1	3	5	2	15+1
8		2	1	4	4+3	1	12+3
5				6	1+2	1+1	8+3
2							0
0			1	1+	1		3+1
	2	4+	3	14+	11+	4+	38+8

Coefficient of Correlation : r = -0.15

Test A

Test J

Scores	0	2	4	6	8	10	
10		1	3	8+1	3	1	16+1
8		1	5+3	5	1		12+3
5		2	3+3	4			9+3
2			1				1
0		2	1+1				3+1
		6	13+	17+	4	1	41+8

Coefficient of Correlation : r = 0.49

INTERCORRELATION DIAGRAM (7)

Test C

Test D

Scores	0	2	5	8	10	
10				2	1	3
8			1	1	1	3
5		1	1	5	2	9
2		2	3	2	2	9
0	10		7	11	3	21+10
	10	3	12	21	9	45+10

Coefficient of Correlation r = 0.36

Test C

Test E

Scores	0	2	5	8	10	
10		1	3	9	2	15
8	1	1	2	2	2	7+1
5			2	3	2	7
2	3	1	3	1		5+3
0	5			4	1	5+5
		3	10	19	7	39+9

Coefficient of Correlation r = 0.39

Test F

Test C

Scores	0	2	5	8	10	
10			3	3	3	9
8			7	6	8	21
5			6	3	3	12
2		1	2			3
0	2		3	5		0+10
	2	1	18+3	12+5	14	45+10

Coefficient of Correlation r = 0.39

INTERCORRELATION DIAGRAM (8)

Test C

Test G

Scores	0	2	5	8	10	
10			3	10	2	15
8	5		2	5	4	11 +5
5	3	2	6	6	1	15+3
2		1	1		1	3
0	2					0 + 2
	10	3	12	21	8	44+10

Coefficient of Correlation: r = 0.31

Test C

Test H

Scores	0	2	5	8	10	
10			1	1	1	3
8		1	6	11	4	22
5	3	1	4	3	2	10+3
2	2			1		1 +2
0	3			1		1 +3
	8	2	11	17	7	37+8

Coefficient of Correlation: r = 0.54

Test C

Test I

Scores	0	2	5	8	10	
10	1		8	8	5	21+1
7	5	3	3	12	4	22+5
3	2		1	1		2 +2
0	2					0 +2
	10	3	12	21	9	45+10

Coefficient of Correlation r = 0.43

INTERCORRELATION DIAGRAM (9)

Test C

	Scores	0	2	5	8	10	
	10	1		3	6	7	16+1
	8	3		4	7	1	12+3
Test J	5	3	1	3	5		9+3
	2			1			1
	0	1	1		2		3+1
		8	2	11	20	8	41+8

Coefficient of Correlation r = 0.36

INTERCORRELATION DIAGRAM (10)

Test D

Test E

Scores	0	2	5	8	10	
10	6	1	5	1	2	15
8	1+1	4	2			7+1
5	4	1	1	1		7
2	3+3	2				5+3
0	5+5					5+5
	19+9	8	8	2	2	39+9

Coefficient of Correlation r = 0.51

Test D

Test F

Scores	0	2	5	8	10	
10	7	1	5	1		14
8	6+5	2	2		2	12+5
5	8+3	6	1	2	1	18+3
2			1			1
0	2					0+2
	21+10	9	9	3	3	45+10

Coefficient of Correlation r = 0.08

Test D

Test G

Scores	0	2	5	8	10	
10	7	2	4	2		15
8	7+5	1	1		2	11+5
5	5+3	5	3	1	1	15+3
2	2	1				3
0	2					0+2
	21+10	9	8	3	3	44+10

Coefficient of Correlation r = 0.00

INTERCORRELATION DIAGRAM (11)

Test D

Test H

Scores	0	2	5	8	10	
10	1		2			3
8	12	3	4		3	22
5	5+3	4		1		10+3
2	1+2					1+2
0	3		1			1+3
	19+8	7	7	1	3	37+8

Coefficient of Correlation : r = 0.25

Test D

Test I

Scores	0	2	5	8	10	
10	13+1	2	4		2	21+1
7	8+5	7	4	2	1	22+5
3	2		1	1		2+2
0	2					0+2
	21+10	9	9	3	3	45+10

Coefficient of Correlation : r = 0.02

Test D

Test J

Scores	0	2	5	8	10	
10	6+1	4	3	1	2	16+1
8	7+3	3	1	1		12+3
5	5+3		3		1	9+3
2	1					1
0	1+1	1	1			3+1
	20+8	8	8	2	3	41+8

Coefficient of Correlation : r = 0.14

INTERCORRELATION DIAGRAM (12)

Test E

Test F

Scores	0	2	5	8	10	
10	1	1		3	6	11
8	3+2	1+2	2	2	3	11+4
5	1+3	3	5	2	5	16+3
2					1	1
0		1		1		0+2
	5+5	5+3	7	7+1	15	39+9

Coefficient of Correlation r = 0.14

Test E

Test G

Scores	0	2	5	8	10	
10	1	1	1	3	7	13
8	2+3	1+1	2	1	2	8+4
5	2+2	2	3	3+1	5	15+3
2		1	1		1	3
0		2				0+2
	5+5	5+3	7	7+1	15	39+9

Coefficient of Correlation : r = 0.22

Test E

Test H

Scores	0	2	5	8	10	
10					3	3
8	3	2	3	3	8	19
5	1+1	2+1	1	4+1	2	10+3
2	2				1	1+2
0	1	2	1			1+3
	4+4	4+3	6	7+1	14	34+8

Coefficient of Correlation : r = 0.32

INTERCORRELATION DIAGRAM (13)

Test E

Test I

Scores	0	2	5	8	10	
10	1+1	2	5	2	8	18+1
7	4+3	3+2	1	5	6	19+5
3	1		1	1	1	2+2
0		1				0+1
	5+5	5+3	7	7+1	15	39+9

Coefficient of Correlation : r = 0.20

Test E

Test J

Scores	0	2	5	8	10	
10	2+1		2	3	5	12+1
8	2+2	2	2	1+1	4	11+3
5	1	2+2	1	2	3	8+3
2			1			1
0	1	1			2	3+1
	4+5	5+2	6	6+1	14	35+8

Coefficient of Correlation : r = 0.06

Test F

Test J

Scores	0	2	5	8	10	
10			6+1	4	6	16+1
8	1		5+2	3	4	12+3
5	1	1	4	1+2	3	9+3
2				1		1
0			1	1+1	1	3+1
	2	1	16+3	10+3	14	41+8

Coefficient of Correlation r = 0.04

INTERCORRELATION DIAGRAM (14)

Test F

Test G

Scores	0	2	5	8	10	
10			2		13	15
8			5+2	6+3		11+5
5	1	1	8+1	6+1		15+3
2			3			3
0	1			1		2
	2	1	18+3	12+5	13	44+10

Coefficient of Correlation r = 0.58

Test F

Test H

Scores	0	2	5	8	10	
10					3	3
8		1	8	8	5	22
5	1		5+1	3+1	2	10+3
2			1+2			1+2
0	1		1	2		1+3
		1	15+3	11+3	10	37+8

Coefficient of Correlation : r = 0.40

Test F

Test I

Scores	0	2	5	8	10	
10			10	4+1	7	21+1
7		1	7+3	7+2	7	22+5
3	1		1	1+1		2+2
0	1			1		0+2
	2	1	18+3	12+5	14	45+10

Coefficient of Correlation 0.27

INTERCORRELATION DIAGRAM (15)

Test G

Test H

Scores	0	2	5	8	10	
10					3	3
8		1	8	8	5	22
5	1	1	3 + 1	2 + 1	4	10+3
2			1 + 1	1		1+2
0	1		1 + 1	1		1+3
	2	2	13+3	10+3	12	37+8

Coefficient of Correlation: r = 0.38

Test G

Test I

Scores	0	2	5	8	10	
10		2	6	4 + 1	7	19+1
7	1	1	7 + 1	7 + 3	8	23+5
3			2 + 2			2+2
0	1			1		0+2
	2	3	15+3	11+5	15	44+10

Coefficient of Correlation : r = 0.04

Test G

Test J

Scores	0	2	5	8	10	
10			4	5 + 1	6	15+1
8		1	4 + 2	2 + 1	5	12+3
5	1	1	3	2 + 2	3	9+3
2			1			1
0		1	1	1	1	3+1
		3	12+3	10+4	15	40+8

Coefficient of Correlation: r = 0.23

INTERCORRELATION DIAGRAM (16)

Test H

Test I

Scores	0	2	5	8	10	
10	1		4	12	3	20
7	1	1+2	6+2	10		17+5
3	1		1			0+2
0	1					0+1
	1+3	1+2	10+3	22	3	37+8

Coefficient of Correlation : r = 0.52

Test H

Test J

Scores	0	2	5	8	10	
10		1	3	9	1	13+1
8		1	3+2	5	2	10+3
5	1+2	1	3	4		9+2
2				1		1
0	1			2		2+1
	1+3	1+2	9+2	21	3	35+7

Coefficient of Correlation ; r = 0.28

Test I

Test J

Scores	0	3	7	10		
10			9+1	7		16+1
8		1	5+2	7		12+3
5	1		4+1	5+1		9+3
2				1		1
0		1	2	1		3+1
	1	2	20+4	21+1		41+8

Coefficient of Correlation : r = 0.11

INTERCORRELATION DIAGRAM (17)

Test A

Post-operative

D.B.P.

mm Hg.	0	2	4	6	8	10	
70							
		1	1	4	2		8
90							
		4	5	7+1	2		19+1
110							
	0+1	1	7+4	4	1		13+5
130							
		1	2+1	3			6+1
150							
			0+3				0+3
170							
	0+1	7	15+[illegible]	18+1	5	0	45+10

Coefficient of Correlation r = 0.28

Test A

Post-operative

Symptom

Grade

%	0	2	4	6	8	10	
100							
		3	12+3	5+1	5		25 + 4
80							
		2	2+2	10			14 + 2
60							
	0+1	1		2			3 + 1
40							
		1	1+2	1			3 +2
20							
			0+1				0 + 1
0							
	0+1	7	15+[illegible]	18+1	5		45 +10

Coefficient of Correlation r = 0.29

Test A

All 10

Pre-operative

Tests

%	0	2	4	6	8	10	
100							
				1	4		5
80							
		3	8	9	1		21
60							
		3	7+3	8			18 +3
40							
	0+1	1	0+4	0+1			1 + 6
20							
			0+1				0 + 1
0							
	0+1	7	15+8	18+1	5		45+10

Coefficient of Correlation r = 0.47

INTERCORRELATION DIAGRAM (18)

Test B

Post-operative D.B.P.

mm Hg.	0	2	4	6	8	10	
70		1		2	4		7
90	1	2+1	2	4	4	3	16+1
110	2	1	2	4+2	2+3	2	13+5
130				6	0+1		6+1
150					0+2	0+1	0+3
170	3	4+1	4	16+2	10+6	5+1	42+10

Coefficient of Correlation r = 0.05

Test B

Post-operative Symptom Grade

%	0	2	4	6	8	10	
100		3+1	3	5+1	9+2	3	23+4
80	2	1	1	8	1+1	0+1	13+2
60				2+1		1	3+1
40	1			1	0+2	1	3+2
20					0+1		0+1
0	3	4+1	4	16+2	10+6	5+1	42+10

Coefficient of Correlation r = -0.04

Test B

All 10 Pre-operative Tests

%	0	2	4	6	8	10	
100				1	1	1	3
80	2	2	2	5	8	2	21
60	1	2	2	9	1+2	2+1	17+3
40		0+1		1+2	0+3		1+6
20					0+1		0+1
0	3	4+1	4	16+2	10+6	5+1	42+10

Coefficient of Correlation r = 0.10

INTERCORRELATION DIAGRAM (19)

Test C

Post-operative D.B.P.

mmHg. 70	0	2	5	8	10	
90			2	2	3	7
110	0+1	2	5	9	3	19+1
130	0+5	1	3	6	3	13+5
150	0+1		2	4		6+1
170	0+3					0+3
	0+10	3	12	21	9	45+10

Coefficient of Correlation r = 0.39

Test C

Post-operative Symptom Grade

% 100	0	2	5	8	10	
80	0+4		9	12	4	25+4
60	0+2	2	3	5	4	14+2
40	0+1			3		3+1
20	0+2	1		1	1	3+2
0	0+1					0+1
	0+10	3	12	21	9	45+10

Coefficient of Correlation r = 0.33

Test C

All 10 Pre-operative Tests

% 100	0	2	5	8	10	
80				1	3	4
60			5	13	4	22
40	0+3	2	7	7	2	18+3
20	0+6	1				1+6
0	0+1					0+1
	0+10	3	12	21	9	45+10

Coefficient of Correlation r = 0.76

INTERCORRELATION DIAGRAM (20)

Test D

Post-operative D.B.P.

mm Hg.	0	2	5	8	10	
70		3	1	2	1	7
90	10 +1	4	3		2	19+1
110	7 +5	1	5			13+5
130	4 +1	1		1		6+1
150	0 +3					0+3
170	21+10	9	9	3	3	45+10

Coefficient of Correlation r = 0.41

Test D

Post-operative Symptom Grade

%	0	2	5	8	10	
100	12 +4	3	6	2	2	25+4
80	6 +2	6		1	1	14 +2
60	2 +1		1			3 + 1
40	1 +2		2			3 + 2
20	0 +1					0 + 1
0	21+10	9	9	3	3	45+10

Coefficient of Correlation r = 0.35

Test D

All 10 Pre-operative Tests

%	0	2	5	8	10	
100			2	1	1	4
80	8	6	5	1	2	22
60	13 +3	2	2	1		18 + 3
40	0 +6	1				1 +6
20	0 +1					0 + 1
0	21+10	9	9	3	3	45+10

Coefficient of Correlation r = 0.56

INTERCORRELATION DIAGRAM (21)

Test E

Post-operative

D.B.P.

mm Hg.	0	2	5	8	10	
70		1		1	4	6
90	1 +1	3	2	3	6	15+1
110	2 +2	0 +2	4	2 +1	4	12+5
130	2 +1	1	1	1	1	6+1
150	0 +1	0 +1				0+2
170	5+5	5+3	7	7+1	15	39+9

Coefficient of Correlation r = 0.50

Test E

Post-operative

Symptom

Grade

%	0	2	5	8	10	
100	2 +4	2	3	3	9	19+4
80	2 +1	2 +1	3	4	3	14+2
60		1 +1			2	3+1
40	1		1	0 +1	1	3+1
20		0 +1				0+1
0	5+5	5+3	7	7+1	15	39+9

Coefficient of Correlation r = 0.12

Test E.

All 10

pre-operative

Tests

%	0	2	5	8	10	
100				1	2	3
80	1		2	5	10	18
60	4 +2	4 +1	5	1	3	17+3
40	0 +3	1 +1		0 +1		1+5
20		0 +1				0+1
0	5+6	5+3	7	7+1	15	39+9

Coefficient of Correlation r = 0.65

INTERCORRELATION DIAGRAM (22)

Test F

Post-operative D.B.P.

mm Hg.	0	2	5	8	10	
70			5	2		7
90			5+1	5	9	19+1
110	0+2	1	5+1	3+2	4	13+5
130			4	2+1		6+1
150			0+1	0+2		0+3
170	0+2	1	19+3	12+5	13	45+10

Coefficient of Correlation r = 0.13

Test F.

Post-operative Symptom Grade

%	0	2	5	8	10	
100			7+2	6+2	12	25+4
80			9+1	4+1	1	14+2
60			2	1+1		3+1
40	0+1	1	1	1+1		3+2
20	0+1					0+1
0	0+2	1	19+3	12+5	13	45+10

Coefficient of Correlation r = 0.56

Test F

All 10 Pre-operative Tests

%	0	2	5	8	10	
100			2		2	4
80			5	7	10	22
60		1	11+1	5+2	1	18+3
40	0+1		1+2	0+3		1+6
20	0+1					0+1
0	0+2	1	19+3	12+5	13	45+10

Coefficient of Correlation r = 0.49

INTERCORRELATION DIAGRAM (23)

Test G

Post-operative D.B.P.

mm Hg.	0	2	5	8	10	
70			2	3	2	7
90		2	3	4+1	9	18+1
110	0+2	1	5+2	3+1	4	13+5
130			5	1+1		6+1
150			0+1	0+2		0+3
170	0+2	3	15+3	11+5	15	44+10

Coefficient of Correlation r = 0.26

Test G

Post-operative Symptom Grade

%	0	2	5	8	10	
100		1	6+2	6+2	12	25+4
80		2	5	3+2	3	13+2
60	0+1		2	1		3+1
40			2+1	1+1		3+2
20	0+1					0+1
0	0+2	3	15+3	11+5	15	44+10

Coefficient of Correlation r = 0.42

Test G

All 10 pre-operative Tests

%	0	2	5	8	10	
100				1	3	4
80			5	5	11	21
60		2	10	5+3	1	18+3
40	0+1	1	0+3	0+2		1+6
20	0+1					0+1
0	0+2	3	15+3	11+5	15	44+10

Coefficient of Correlation r = 0.62

INTERCORRELATION DIAGRAM (24)

Test H

Post-operative

D.B.P.

mm Hg.	0	2	5	8	10	
70			2	4		6
90		0+1	7	7	2	16+1
110	1+2		1+3	7	1	10+5
130		1		4		5
150	0+1	0+1				0+2
170	1+3	1+2	10+3	22	3	37+8

Coefficient of Correlation r = 0.27

Test H

Post-operative

Symptom

Grade

%	0	2	5	8	10	
100	0+1	0+2	3	15	3	21+3
80	0+1		7+1	4		11+2
60		1	0+1	1		2+1
40	1		0+1	2		3+1
320	0+1					0+1
0	1+3	1+2	10+3	22	3	37+8

Coefficient of Correlation r = 0.44

Test H

All 10

pre-operative

Tests

%	0	2	5	8	10	
100				2	1	3
80			5	11	2	18
60	1+1	1	5+1	9		16+2
40	0+1	0+2	0+2			0+5
20	0+1					0+1
0	1+3	1+2	10+3	22	3	37+8

Coefficient of Correlation r = 0.71

INTERCORRELATION DIAGRAM (25)

Test I

Post-operative D.B.P.

mm Hg.	0	3	7	10	
70			5	2	7
90			9 +1	10	19+1
110	0 +1	1 +2	4 +2	8	13+5
130		1	4	1 +1	6+1
150	0 +1		0 +2		0+3
170	0+2	2+2	22+5	21+1	45+10

Coefficient of Correlation r = 0.31

Test I

Post-operative Symptom Grade

%	0	3	7	10	
100		1 +1	11 +2	13 +1	25+4
80			7 +2	7	14+2
60		1	2 +1		3+1
40	0 +1	0 +1	2	1	3+2
20	0 +1				0+1
0	0+2	2+2	22+5	21+1	45+10

Coefficient of Correlation r = 0.48

Test I

All 10 pre-operative Tests

%	0	3	7	10	
100			2	2	4
80		1	11	10	22
60		1	8 +2	9 +1	18+3
40	0 +1	0 +2	1 +3		1+6
20	0 +1				0+1
0	0+2	2+2	22+5	21+1	45+10

Coefficient of Correlation r = 0.50

INTERCORRELATION DIAGRAM (26)

Test J

Post-operative D.B.P.

mm Hg.	0	2	5	8	10	
70				2	5	7
90	1		5	5	7+1	18+1
110	2+1	1	2+1	3+2	4	12+4
130			2+1	2	1	5+1
150			0+1	0+1		0+2
170	3+1	1	9+3	12+3	17+1	42+8

Coefficient of Correlation r = 0.40

Test J

Post-operative Symptom Grade

%	0	2	5	8	10	
100	2	1	3	8+2	11+1	25+3
80	1+1		2	4+1	6	13+2
60			2+1			2+1
40			2+1			2+1
20			0+1			0+1
0	3+1	1	9+3	12+3	17+1	42+8

Coefficient of Correlation r = 0.22

Test J

All 10 pre-operative Tests

%	0	2	5	8	10	
100					5	5
80	2		3	6	10	21
60		1	6+1	6+1	2+1	15+3
40	1+1		0+2	0+1		1+4
20			0+1			0+1
0	3+1	1	9+4	12+2	17+1	42+8

Coefficient of Correlation r = 0.49

INTERCORRELATION DIAGRAM (27)

All 10 Pre-operative Tests

Post-operative D.B.P.

mm Hg.	0	20	40	60	80	100%
70			1	4	2	7
90		1 +1	5	12	1	19+1
110	0 +1	0 +3	7 +1	5	1	13+5
130			5 +1	1		6+1
150		0 +2	0 +1			0+3
170	0+1	1+6	18+3	22	4	45+10

Coefficient of Correlation r = 0.56

All 10 pre-operative Tests

Post-operative Symptom Grade

%	0	70	40	60	80	100%
100		0 +3	7 +1	15	3	25+4
80		1	6 +2	6	1	14+2
60		0 +1	2	1		3+1
40		0 +2	3			3+2
20	0 +1					0+1
0	0+1	1+6	18+3	22	4	45+10

Coefficient of Correlation r = 0.61

Post-operative Symptom Grade

Post-operative D.B.P.

mm Hg.	0	20	40	60	80	100%
70				3	4	7
90				6	13 +1	19+1
110	0 +1	3 +1	1 +1	2 +1	7 +1	13+5
130			2	3	1 +1	6+1
150		0 +1		0 +1	0 +1	0+3
170	0+1	3+2	3+1	14+2	25+4	45+10

Coefficient of Correlation r = 0.22