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COMMUNICATIONS

CHANGES IN THE FUNDUS OCULI FOLLOWING SPLANCHNECTOMY IN MALIGNANT HYPERTENSION

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MONTREAL

FIFTEEN cases of malignant hypertension treated by supradia-phragmatic splanchnectomy are reported. From every standpoint, including that of the fundus oculi, two were cured, three markedly improved, eight moderately improved and one unchanged. However, the improvement in the fundus oculi was the most dramatic.

In June, 1937, a presentation was made to the members of this Section entitled "Essential cardiovascular hypertension as revealed in examination of the fundus oculi."¹ It may be remembered that a general survey of something like 400 cases of hypertension occurring in the wards of the Royal Victoria Hospital, Montreal, was made and of these, 100 cases were put aside as representing clinically and ophthalmoscopically a classification known as essential hypertension. A certain number of these represented a series

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relatively malignant in character, sometimes by the picture revealed in the fundus oculi, at other times through the alarmingly high blood pressure which the routine clinical examination brought out. Frequently the two went together, but it did not of necessity follow that the two had to occur together. In these cases of so-called malignant or relatively malignant form, the ophthalmoscopic picture varied from those cases which seemed to be free from any hypertensive lesion to others where oedematous changes in the fundus were so intense that retinal details could only be made out with the greatest difficulty. Certain patients selected as suitable for surgical consideration were transferred to the Department of Neuro-surgery where operative interference was instituted after consultation with members of the staff of that institution. We have attempted after a reasonable delay following operation to repeat our former examination, not only recording the ophthalmoscopic picture, but also the blood pressure, the state of the blood chemistry and one or two other details, comparing them with those recorded before operative measures were undertaken.

Something like 20 cases were operated upon and of these, 15 are now being reviewed. The whole number now being taken into consideration were simply reported *seriatim* and not selectively. Those omitted were unable to attend through a residence remote from the city which made their attendance a hardship.

We have been fortunate in obtaining the eye of one patient suffering from malignant cardiovascular hypertension who was deemed unsuitable for operation owing to her age and to the extent of renal involvement. A brief clinical summary as well as the pathological findings show us what subsequently we have to anticipate in both these realms of consideration in the cases which are to follow.

Mrs. H. S., aged 51 years, married and the mother of ten children, was admitted to the Royal Victoria Hospital in February 1937, and died about three weeks later. Her condition was diagnosed as one of "malignant hypertension with hypertensive heart disease and nephritis with generalised arteriosclerosis." Her blood pressure on admission was 280/140, with 2 plus albumen and a trace of sugar in the urine. Strangely enough, her creatinine on admission registered only 1.42 mgms. per cent., and non-protein nitrogen only 26.6 mgms. per cent. These two, however, increased rapidly, so that the day before death creatinine registered 14.2 mgms. per cent., and non-protein nitrogen 286 mgms. per cent. These two signified very definite renal involvement associated with the arteriosclerosis and the essential cardiovascular hypertension.

The patient was seen by the neuro-surgeons who deemed that a splanchnectomy was not to be attempted owing to her age and also on account of the renal involvement.

Her fundi were examined shortly after admission and the picture revealed was described as follows: "One seldom sees a more intense degree of neuro-retinal oedema. The disc is so swollen that there is absolutely no sign of its margin, and the lamina cribrosa is completely filled in. The veins, as they emerge, are terribly engorged, tortuous and buckled, practically at every point where crossed by the arteries, while the arteries themselves are definitely contracted. Lymph exudates as well as haemorrhages cover the walls of the arteries as they emerge from the

disc, and numbers of flame-shaped haemorrhages follow the vessel walls and are also scattered indiscriminately throughout the retina. The retina about the macular area in both eyes is one large lymph plaque, while there are other deposits of lymph scattered throughout the oedematous membrane at too many points to specify."

The patient was seen repeatedly up to one day prior to her death. An autopsy was performed which revealed a genuine productive nephritis, hypertrophy of the

FIG. 1.

Shallow detachment of the retina from choroid. Atheromatous changes in vessels almost up to a point of occlusion. Degenerative changes in choroidal pigment. Multiple haemorrhages between internal and external granular layer of the retina.

heart, productive pleurisy, haemorrhagic oedema of the lungs, generalised hypertrophic arteriosclerosis, petechial haemorrhages in the colon, bladder, renal pelvis, ureter and stomach.

A brief description of the pathological changes occurring in the eyeball are as follows: The cornea, sclera, anterior chamber, iris, ciliary body and lens were normal. The choroid showed patchy collapse and engorgement. In the latter areas there was much serum exudate in which a few leucocytes could be seen.

Over these latter areas the retina and pigment epithelium showed a shallow detachment caused by the same type of exudate. The retina here and there showed small haemorrhagic extravasations into the deeper layers. (Fig. 1.) One area was very large being about 100 micra in diameter; in another area the same picture could be seen in a healing stage. The haemorrhage had been resorbed and the retinal layers could no longer be recognised as such, but were largely replaced by glia and fibrous tissue. In general, the retina showed patchy degeneration of the rod and cone layer, marked by pyknotic changes in the nuclei and loss of the outer limbs. There was marked cystic degeneration of the outer reticular layer in the region of

FIG. 2.

Definite oedematous changes in optic nerve itself as well as on surface of disc. Central vein dilated, with extravasation of leucocytes or perivasculitis along vessel wall, lamina cribrosa gradually being filled in.

the ora serrata. The retinal arteries were markedly thickened and in some places showed hyalin degeneration of their coats, and were more deeply placed than they should be in the region of the optic disc. The retinal veins were engorged. The vessels of the choroid showed a marked degree of arteriosclerosis (Fig. 1).

The swelling of the nerve head seen before death ophthalmoscopically was due to oedema and shallow detachment of the retina about the optic nerve (Figs. 2 and 3). The oedema was of marked degree as it contained numerous leucocytes, and the outer layers of the retina had degenerated.

Such, of course, is an extreme picture, but it may in some measure assist us in appreciating clinically the following series of cases which we are attempting to describe in detail where operative intervention was instituted after the cases had been carefully considered from a surgical standpoint.

Case No. 1, male, aged 36 years. Blood pressure 220/140. Pre-operative fundus examination: "Both fundi suggest rather an early phase of retinal arteriosclerosis. The light reflex on the arterial wall is very distinct while the smaller arteries are contracted. Both the smaller arteries and veins as they approach the capillary type are disposed to be tortuous. There is distinct evidence of buckling on the part of the superior temporal vein in both eyes where the arteries cross them." Post-operative fundus examination: 698 days following operation. "Right eye: The arteries are markedly contracted, more particularly the small ones. The arterial walls are highly refractile, especially close to the nerve head. The veins are very

FIG. 3.

Shallow detachment of retina, generalised pigmentary degeneration of choroid. Splitting or separation of fibres of Müller almost up to the nerve fibre layer particularly well shown with extravasation of lymph between these fibres.

definitely engorged and tortuous with very marked buckling where the smaller contracted arteries cross them; note particularly the right superior temporal vein. There are quantities of lymph plaques, some distributed relatively close to the disc margin below, another one about two discs' diameter above at a point where a vein is buckled by a smaller arteriole. Left eye: Shows arteries in many respects comparable to those of the right eye, but perhaps with not the same degree of sclerosis. The veins are engorged but not quite so tortuous, with buckling of the superior nasal vein about two discs' diameter from the disc margin. There are no lymph plaques in this eye, and no haemorrhages in either eye. Vision 6/6 in each eye." Blood pressure 210/150.

Case No. 2, female, aged 28 years. Blood pressure 228/140. Pre-operative fundus examination: "There is quite a definite blurring about the nasal as well as

FIG. 4.

Large psammoma body in pia arachnoid sheath of the optic nerve. In appearance it simulates an advanced condition of arterial sclerosis with endarteritis obliterans.

about the upper margin of the nerve head. The smaller vessels in this neighbourhood are apparently covered with lymph exudate. The laminae cribrosae are not sharply outlined. The arteries may possibly be contracted but the veins are not engorged or tortuous or grooved where the arteries cross them." Post-operative fundus examination 639 days following operation: "Right eye: There is a slight increase in the light reflex along the arterial walls, but hardly what one would describe as a generalised contracture of the vessels, although some of the smaller branches are certainly so disposed. The veins are somewhat engorged, as one would expect to find in this type of individual with her body weight; but no degree of buckling is discernible. There are no haemorrhages or lymph exudates. Left eye: Manifests precisely the same picture, and were one not put on one's guard, one would describe it as normal. Vision in each eye 6/6 partly, with correction." Blood pressure 120/80.

Case No. 3, female, aged 51 years. Blood pressure 280/145. Pre-operative fundus examination: "The right eye shows very definitely cardiovascular changes. The arteries are very markedly contracted and their walls are highly refractile. The veins are tremendously engorged and tortuous and dipped at many points where the arteries cross them. At the upper margin there is a large plaque of lymph exudate covering the vessels. It is so absolutely defined that it is almost suggestive of an area of persistent medullary sheaths. The rest of the disc margin is clear. In the left fundus the disc as such can be clearly outlined but the whole retina is such a mass of oedematous change that it is practically impossible to describe it. There is hardly a portion of retina proximal to the optic disc that one can recognise

as such, and being free from lymph exudate. The whole of the macular area is simply one enormous conglomerate mass of greyish-white oedematous change extending over this and away beyond the actual adjacent area. There are no haemorrhages in either eye." Post-operative fundus examination—440 days following operation: Right eye: "The arteries are generally sclerosed and the veins are engorged and tortuous. They are buckled close to the nerve head above. There is a blurring of the upper margin of the disc at about '11 o'clock,' caused by a very large plaque of lymph exudate with which is associated a haemorrhage. The macular area is clear. Left eye: shows a complete block of the inferior temporal artery. The veins throughout are generally engorged and tortuous, with multiple buckling. There are characteristic white lines along the course of the inferior temporal veins. The arteries are generally sclerosed and tortuous. There is a large plaque of lymph with pigmentary change close to if not directly at the macular area. There is also one large plaque of lymph exudate less than one disc diameter from the disc margin, above and to the nasal side. There are also a few mottled lymph plaques fairly close to the nerve head at the nasal side below." Right vision 6/6. Left vision—fingers at 4 metres. Cannot get fingers at 1 metre above mid-line. Blood pressure 200/140.

Case No. 4, female, aged 49 years. Blood pressure 260/140. Pre-operative fundus examination: "There is a well marked papillitis of both eyes with marked tortuosity of veins and contraction of arteries. Numerous recent small flame-shaped haemorrhages around the nerve head and throughout the fundi. The macular area seems free from involvement. Small scattered, round, dark areas of older haemorrhages in temporal region. No atrophy of the retina. Two subsequent examinations upheld these findings." Post-operative fundus examination—330 days following operation: "A most startling manifestation for the better in both fundi is apparent. Naturally the veins, as formerly, are definitely tortuous and nicked or notched at numbers of places where crossed by the arteries, as formerly noted. It is equally true that the arteries manifest their former contracted sclerosed condition; but absolutely no manifestation of loss of compensation is apparent in the presence of either haemorrhages or of lymph exudates which were so clearly evident prior to her operation. A month or two ago the residue of this loss of compensation could be seen as relatively small stippled lymph plaques at the temporal side of each nerve head. These have now completely disappeared. Vision, right eye 6/36, which has always been amblyopic, associated with convergent squint. Vision, left eye 6/9. Both eyes are highly astigmatic." Blood pressure 270/110.

Case No. 5, female, aged 36 years. Blood pressure 220/150. Pre-operative fundus examination: "Right eye—there are two patches of white exudate just temporal to the disc and above the macula. They are along a ciliary retinal artery. There are a couple of small haemorrhages along the macular branch of the inferior temporal vein, with a white patch of exudate beside them. The calibre of the superior nasal artery varies. The disc margin is blurred. Left eye—there is blurring of the disc margins. The arteries are very narrow, the veins fairly wide with variation of calibre, especially marked in the inferior temporal artery. There are no haemorrhages and no patches of exudate." Post-operative fundus examination—345 days following operation: "Right eye—blurring about vessels at upper nasal side of disc margin. Tiny pinhead patch of lymph exudate along the superior temporal artery about two discs' diameter from the disc margin. The veins may possibly be somewhat engorged with a moderate indication of nicking by some of the small arterial capillaries relatively close to the margin of the disc. Vision 6/6 in each eye." Blood pressure 260/140.

Case No. 6, female, aged 43 years. Blood pressure 182/114. Pre-operative fundus examination: "The arteries are a little narrow and there is decided pitting or compression of the inferior and superior temporal vessels in the left eye. The transparency of the vessels seems good. I should think from the picture that this is a straight case of hypertension of a very long standing." Post-operative fundus examination: 87 days following operation. "There is a moderate degree of tortuosity of the veins. They are not engorged or buckled. The arteries are possibly

slightly thinner than normal. If one had no information on her medical condition one would have said the fundi were normal." Vision 6/6 in each eye. Blood pressure 210/130

Case No. 7, male, aged 53 years. Blood pressure 210/130. Pre-operative fundus examination: "There are absolutely no signs in either fundus of localised cardiovascular hypertension. The discs are sharply outlined and of good colour and the veins are not engorged, tortuous or buckled. The arteries, both large and small, show no degree of contraction, and the light reflexes on their walls show no evidence of exaggeration. There are no haemorrhages or lymph exudates." Post-operative fundus examination—455 days following operation: "Right eye—disc of good colour and sharply defined. The veins are somewhat engorged and slightly tortuous, but not nicked at any point. The arteries have no heightened reflex on their wall and they do not appear to be contracted. Would be pronounced as normal had he presented himself otherwise. No haemorrhages or lymph exudates. Left eye—the same statement holds for this eye." Vision 6/6 partly in each eye. Blood pressure 220/135.

Case No. 8, male, aged 30 years. Blood pressure 172/120. Pre-operative fundus examination: "The right eye is definitely myopic and the left eye is hypermetropic. No changes in the fundi except possibly secondary anaemia." Post-operative fundus examination—505 days following operation: "Right eye—an absolutely clear view of the right fundus is somewhat inhibited from what appears to be an anterior polar cataract, of course, congenital or immediately post-natal in origin. There is no manifest scarring of the cornea as far as one can visualise. On looking around this opacity in the lens the details of the fundus appear to be absolutely clear and normal. Left eye—the fundus is normal in all details." Vision—right eye amblyopic, convergent squint, anterior polar cataract. Vision, left eye 6/6 with correction. Blood pressure 170/100.

Case No. 9, male, aged 46 years. Blood pressure 204/160. Pre-operative fundus examination: "Physiological cupping of the discs which are clearly outlined. The retinal vessels appear normal. No haemorrhages or exudates." Post-operative fundus examination—425 days following operation: "Right eye: The arteries are not contracted and do not show heightened light reflex on either the main branches or the more distant capillaries. The veins are not unduly engorged, tortuous or nicked. No haemorrhages or lymph exudates. Left eye: Similar statement holds for this eye. Would pronounce both fundi as normal. Vision 6/6 partly in each eye. Blood pressure 200/120.

Case No. 10, male, aged 22 years. Blood pressure 164/100. Pre-operative fundus examination: The fundi were normal. Post-operative fundus examination—260 days following operation: "Both eyes—fundus should be declared as normal in every particular." Vision 6/6 in each eye. Blood pressure 115/110.

Case No. 11, male, aged 45 years. Blood pressure 240/126. Pre-operative fundus examination: "Left eye—the arteries are very narrow, but the inferior temporal fairly cuts the dilated vein. There are white patches of exudate, of the cotton-wool variety, around the disc, two on the nasal side, two along the inferior temporal artery, and one just above the superior temporal vein. Many pigment dots at the end of the vessels in the macular area. There is a little swelling of the nasal side of the nerve head, but not enough to measure. Right eye—shows the same picture. The white patches of exudate are smaller but more numerous, there being 8 or 9 just above the macula as well as some on the nasal side. The nerve head is distinctly blurred and swollen. The amount of swelling is chiefly at the nasal side, being about 1 dioptre." Post-operative fundus examination—310 days following operation: "Right eye—somewhat heightened light reflex on the superior temporal artery close to the nerve head where the underlying vein is somewhat engorged and very slightly nicked. A tiny arteriole coming off this branch close to the lamina

cribrosa shows the result of blockage and small flame-shaped haemorrhage. The arteries as a whole are disposed to be contracted. Left eye—the disc is somewhat pale. The arteries, as in the other eye, are contracted, particularly the left superior nasal. The veins are moderately engorged, but not unduly so and are not nicked to any appreciable extent, if at all. A few pigmented changes of the retina, probably the residue of former haemorrhages along the course of the inferior nasal vein. Also some pigmented changes of the same character in the neighbourhood of but not actually in the macular area. Vision 6/6 in each eye." Blood pressure 190/130.

Case No. 12, female, aged 34 years. Blood pressure 170/100. Pre-operative fundus examination: "There is some indistinctness of the nasal margins of both discs. This appears to be within normal limits. The arteries are of smaller calibre than one would expect for a person of this age, and there is an increased light reflex. The veins are nicked where crossed by the arteries, but otherwise the veins are not remarkable." Post-operative fundus examination—330 days following operation: "In both eyes the arteries at times appear to be normal. In other instances there is a definite contracture of the arterial wall with occasional heightened reflex. On the whole I would consider the arteries as being reduced in calibre. There is one small capillary on the temporal side of the right optic disc quite close to the descending branches of the vein and artery which appears as a tiny silver thread or wire and then disappears. The veins are relatively engorged and tortuous but not buckled, at least not to any appreciable degree. There are no haemorrhages and no lymph exudates." Vision 6/6 partly in each eye. Blood pressure 165/120.

Case No. 13, female, aged 43 years. Blood pressure between 240/120 and 120/90. Pre-operative fundus examination: "There are a few peripheral opacities in each lens. Media are otherwise clear. Discs of normal colour and have a sharp outline. The arteries are somewhat attenuated and groove the veins at their crossings. There are no haemorrhages or exudates." Post-operative fundus examination—325 days following operation: "Both discs are normal in calibre and outline. The arteries are slightly thickened and narrower than normal. The veins are slightly buckled where crossed by the arteries. There are no haemorrhages or patches of lymph exudate." Vision 6/6 in each eye. Blood pressure 175/120.

Case No. 14, female, aged 49 years. Blood pressure 198/110. Pre-operative fundus examination: "Both discs of good colour and well defined. The retinal arterioles are narrow but are not tortuous. The veins are engorged and there is arterial nicking. The physiological cups are somewhat indistinct." Post-operative fundus examination—750 days following operation: "I would pronounce these fundi as being absolutely normal in all particulars had I not been put on my guard. Some of the smaller arterial capillaries may possibly be contracted, but such an observation is vague to say the least. The arterial walls are not highly refractile, while the veins are not engorged, tortuous or bent, and there is not the slightest evidence of exudates of any kind in the retinal stroma." Vision in each eye 6/7 partly. Blood pressure 210/125.

Case No. 15, female, aged 29 years. Blood pressure 210/143. Pre-operative fundus examination: "The veins on both sides are enlarged and pulsate. In many places they are compressed almost completely by arteries which cross them." Post-operative fundus examination—1065 days following operation: "Right eye—both the arteries and the veins are disposed to be somewhat tortuous. The veins are definitely notched, note both the superior temporal and the superior nasal vein relatively close to the nerve head. Left eye—shows a relative contracture of the smaller arteries with compensatory dilatation of the veins but without the tortuosity noted in the right eye. There is no buckling in this instance or any other sign of loss of compensation." Vision 6/6 in each eye. Blood pressure 200/150.

PRE-OPERATIVE.

Case No.	Age	Sex	B.P.	BLOOD CHEMISTRY				URINE			Days P.O.
				N.P.N.	Creat.	Urea	Uric	Sp. Gr.	Alb.	Casts	
1.	36	M	$\frac{210}{140}$	69.6	1.85	—	—	1010	3+	G & H	^{8 b1} 698
2.	28	F	$\frac{228}{140}$	21.7	1.07	—	—	1010	Tr.	O	639
3.	51	F	$\frac{280}{145}$	20.9	1.03	13.0	—	1005	Tr.	O	440
4.	49	F	$\frac{260}{140}$	22.2	1.11	—	3.61	1018	Tr.	H rare	330
5.	36	F	$\frac{260}{140}$	23.6	1.00	—	3.33	1026	O	O	345
6.	43	F	$\frac{240}{128}$	25.6	1.12	13.6	—	1022	O	O	87
7.	53	M	$\frac{210}{130}$	—	1.60	20.0	3.70	1028	O	O	455
8.	30	M	$\frac{172}{120}$	28.8	1.30	—	3.40	1020	Tr.	H & G	505
9.	46	M	$\frac{204}{160}$	26.5	1.12	—	—	1020	O	O	425
10.	22	M	$\frac{176}{115}$	19.4	1.17	—	—	1020	O	O	260
11.	45	M	$\frac{240}{126}$	23.5	1.30	—	—	1018	3+	H rare	310
12.	34	F	$\frac{220}{115}$	23.5	1.07	—	3.47	1016	O	O	330
13.	43	F	$\frac{240}{120}$	23.8	—	—	—	1027	O	O	325
14.	49	F	$\frac{198}{110}$	17.5	—	—	2.21	1031	O	O	750
15.	29	F	$\frac{210}{143}$	25.3	1.18	—	—	1015	O	H rare	1065

NOTE.—Tr. = trace. G. = granular. H. = hyaline. P.O. = post-operative.

POST-OPERATIVE.

B.P.	BLOOD CHEMISTRY				URINE			REMARKS
	N.P.N.	Creat.	Urea	Uric	Sp. Gr.	Alb.	Casts	
210 150 120 80 200 140 270 110 250 145 210 130 220 135 170 100 200 120 155 110 190 130 165 120 175 120 210 125 200 150	92.4 19.0 27.6 20.0 20.2 28.6 27.0 25.0 21.6 24.5 50.0 24.8 20.2 20.0 25.0	4.28 1.35 1.50 1.06 1.06 1.36 1.12 1.06 1.16 1.11 1.50 1.10 1.03 1.00 1.06	— 12.9 16.2 — — — 14.7 — — — — — — — —	82.7 — — — — — — 3.50 — — — — — — —	1010 1012 1022 1012 1022 1022 1020 1020 1028 1026 1016 1030 1028 1020 1016	O O O O O O O O O O 2+ O O O O	O H & G O H Rare H Rare O O O O H O O O O	Past month symptoms worse. Fundus and blood chem. worse. Fundus and symptoms cured. Fundus and symptoms improved. Fundus and symptoms improved. Symptoms improved. Fundus slightly improved. Fundus and symptoms improved. Symptoms improved. Fundus normal before and after operation. Symptoms improved. Fundus normal before and after operation. Symptoms improved. Fundus normal after operation. Symptoms improved. Fundus normal before and after operations. Symptoms improved. Fundus improved. Blood chem. and urine worse. Symptoms and fundus improved. Symptoms and fundus improved. Symptoms and fundus improved. Symptoms improved. Fundus: arteries contracted, unchanged after operation.

NOTE.—Tr. = trace. G. = granular. H. = hyaline. P.O. = post-operative.

Discussion

With the exception of case 1, which continued to follow a malignant course and in which the fundus findings became more involved following operation, improvement, or at least an arrested development in complications involving the fundus oculi, appeared to be the case in our series. From every standpoint, including that of the fundus oculi, 2 were cured, 3 were markedly improved, 8 moderately improved, and 1 unchanged. The fundus oculi frequently appeared to be a barometer of the general well-being of the patient. The changes, as they were recorded for the better, simply reflected the general lowering of the blood pressure and the improvement in the blood chemistry and urine findings. Of all these changes the improvement in the fundus findings and visual acuity were possibly the most dramatic. It should be observed, as we have already pointed out,¹ that an absence of retinal lesions was noted in 28.6 per cent. in a relatively large series of cases of essential cardiovascular hypertension. In the present series, relatively and of necessity much fewer in number, an absence of fundus changes was noted both before and after operation in 37 per cent., which, if allowing for the statistical error inherent in small numbers, would not be out of keeping with our previous figures. One cannot overlook the much larger series of cases of a similar character reported by Fralick and Peet² where a comparable surgical procedure was undertaken. After reviewing their series, our percentage of cases, where an improvement in the fundus oculi was observed, might be recorded as most encouraging.

The question will quite logically be raised; in how far were these cases malignant in character, and what would have been the patient's expectancy of life had operative interference not been undertaken? The clinician's reply is, that had interference not been undertaken death would have ensued within days or weeks at the latest. Indeed, one patient (Case 11) was operated upon only on the strongest possible insistence of the clinician and following the greatest discouragement on the part of the neuro-surgeon. According to Keith, Wagener and Kernohan,³ in their 81 cases with malignant hypertension, the average length of life after diagnosis was eight months. Two patients operated upon, not recorded in this series, died before this review was taken under consideration. Although the ophthalmoscopic findings in these patients at the time of operation were in our possession, the subsequent ophthalmoscopic and clinical findings could not be placed on record, as has been done in the case of those who survived. Hence, these cases have not been included in this series.

The operation used in the present series of cases has been fully described elsewhere by Penfield and Cone.¹ A section of the 11th rib near the spine is removed and the sympathetic chain exposed.

The 9th, 10th, 11th, and 12th thoracic ganglia are removed and also sections in the greater, lesser and least splanchnic nerves. This operation is closely comparable to that of Peet and his co-workers. In our series of cases no other type of operation was used, such as that of anterior root section (Allen and Adson⁵) and infradiaphragmatic sympathectomy (Craig and Brown⁶). In all types of operation the physiological result seems to be about the same. As illustrated in this series, an initial fall of blood pressure usually occurs, followed by a rise approaching the pre-operative level. In only a few is the blood pressure maintained at a lower level. The present results are in agreement with those of Allen and Adson, Freyburg and Peet,⁷ Page and Heuer.⁸

Considerable light has been thrown upon the effect of these operations by the experiments of Goldblatt, Lynch, Hanzal, and Summerville,⁹ who brought about hypertension in dogs by the production of renal ischaemia. Their work was confirmed by Wood and Cash.¹⁰ It is interesting to note that Grimson, Wilson and Phemister¹¹ found the same variable results in the blood pressure after splanchnic sympathectomy in normal dogs. Also Goldblatt, Gross and Hanzal¹² obtained these results after sympathectomy in dogs suffering from experimental hypertension. This return to the level of the pre-operative blood pressure is not surprising when one takes into consideration the physiological factors entering into the production of hypertension. These factors are understood poorly as yet. On the other hand, the histological vascular changes in hypertension are well understood. Hypertension has been shown by numerous experimenters to be due to contraction of the small arteries and arterioles, thus impeding the blood flow. As Ricker¹³ has pointed out, perivascular pathological changes take place when the capillaries dilate, owing to fatigue, while the arteriolar contraction is maintained. When this occurs diapedesis and exudation take place. These facts are well accepted, but there is much controversy over the point as to what produces the vasospasm. Normal vascular tone is partly due to nervous influences. Thus after denervation there is vasodilatation and a drop of blood pressure. But after such a procedure vasodilatation is not complete. Hence, one must postulate the presence of some chemical substances which help to maintain vascular tone. Some such substances are well known, namely, adrenaline, and the pressor substance from the anterior lobe of the pituitary. The experiment of Goldblatt, Lynch, Hanzal and Summerville mentioned above, indicates that possibly some pressor substance is liberated from the kidney under conditions of ischaemia. Hypertension, then, in the first instance may be caused by a preponderance of any of these factors. There are those who argue in favour of a nervous origin and those who argue in favour of a chemical origin. It is possible,

if not probable, that all play a part; the chemical balancing or compensating for any deficiency in the nervous factor under normal conditions. Later, of course, pathological changes take place in the artery walls which maintain the obstruction to the blood flow. Splanchnectomy produces its effect possibly by several methods, denervation of the splanchnic vessels, the adrenals, and the relief of renal ischaemia. But these results are only temporary. Some compensating mechanism comes into action. The result is that the patient's blood pressure rises to the pre-operative level; but with this difference that there are less perivascular changes as seen in the fundus oculi and the patient is symptomatically improved. This probably can be accounted for by the presence of a large denervated vascular area which acts as a safety valve, thus relieving the patient of sudden changes in the blood pressure. Denervation of the adrenals probably contributes in this effect. Such action is important, as it is probable that sudden changes in blood pressure are what cause the damage to vital organs. It is during such occasions that diapedesis and perivascular exudation are most likely to take place.

Thus, in conclusion, it may be stated that, by and large, this operation is disappointing in its effect on the blood pressure level, but, nevertheless, the patients are improved, when one takes into consideration symptoms and fundus findings. Until we know more about the causation of hypertension this is justification enough for such a radical procedure to be undertaken in selected cases. Certain it is that patients suffering from malignant hypertension follow a steady downhill course and deterioration of vision occurs in the absence of such interference. This operation must not be considered as a factor which eliminates the cause of cardiovascular hypertension, but rather as one which arrests its complicating features.

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THE TABETIC PUPIL

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SENIOR SURGEON, LIVERPOOL EYE AND EAR INFIRMARY,
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THE normal movements of the iris are brought about by reflex stimulation of the three intrinsic ocular muscles.

1. The dilator iridis.
2. The constrictor iridis.
3. The ciliary muscle.

Associated with the action of each muscle is a primary nervous reflex.

1. The dilator reflex.
2. The constrictor reflex.
3. The accommodation reflex.

In order to appreciate the significance of abnormalities in the movements and size of the pupil in disease, it is essential to have a clear idea of the anatomy of the various pathways on both the afferent and efferent sides.