TOTAL THORACIC AND PARTIAL TO TOTAL LUMBAR SYMPATHECTOMY AND CELIAC GANGLIONECTOMY IN THE TREATMENT OF HYPERTENSION*

KEITH S. GRIMSON, M.D.

CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY, THE UNIVERSITY OF CHICAGO, CHICAGO, ILL.

RECENT SURGICAL TREATMENT of hypertension has been directed, primarily, toward a sympathetic denervation of the splanchnic area. Several approaches have been employed. Ventral rhizotomy consisting of intraspinal section of the lower six thoracic and first two lumbar anterior spinal nerve roots has been employed in a limited number of patients. Adson, Craig, and Brown[1] report 27 patients, and Heuer[2] 21 patients treated and studied by him and Page. Both reports show a limited incidence of serious surgical complications, and the procedure appears to have been abandoned. Subdiaphragmatic resection of the splanchnic nerves and part of the celiac ganglia together with resection of the first and second lumbar ganglia has been employed by Adson. Allen and Adson reported its use in a series of over 300 cases, without an operative death. Blood pressure reduction is given as good or fair in 31 per cent, and temporary or poor in 69 per cent of their patients. Supradiaphragmatic extrapleural splanchnicectomy consisting of resection of a long section of the greater splanchnic nerves above the diaphragm together with the tenth, eleventh, and twelfth thoracic ganglia, the intervening sympathetic chain, and the lesser splanchnic nerves, has been employed by Peet in more than 700 patients. Studies of 350 of these patients have been reported by Peet, Woods, and Braden.[4] There was a 51.4 per cent significant reduction in blood pressure. They have operated upon many patients with advanced hypertension. Their operative mortality is given as 3.4 per cent.

Celiac ganglionectomy and denervation of the peri-aortic complex of sympathetic nerves and ganglia has been carried out by Crile[5] in 213 patients. Transdiaphragmatic removal of the lower four thoracic and first, or first and second lumbar sympathetic trunk ganglia together with a long segment of the splanchnic nerve has been performed by Smithwick[6] in a large series of patients. Emphasis is placed upon the importance of the postoperative postural hypotension achieved.

A review of these reports and of reports of smaller series of similar operations performed by other surgeons gives the impression that although worthwhile improvements have been obtained in some patients, the therapeutic results, as a whole, have left much to be desired. Clinical and symptomatic benefit have been reported much more frequently than blood pressure lowering. A proper evaluation of the effect of any form of therapy in hypertension is always difficult because of the variety of the symptoms encountered and the

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difficulty of establishing a definite control. The value of splanchnic area denervation in hypertension has been extensively debated.

The rôle of the sympathetic nervous system in experimental neurogenic and renal types of hypertension has been reviewed in a previous report.[7] It has been demonstrated that splanchnic area denervation does not appreciably alter a normal dog's blood pressure, or the hypertensive response to increased intracranial pressure, or the level of the chronic neurogenic hypetension that follows division of the buffer or depressor nerves from the carotid sinuses, heart, and aortic arch. Complete paravertebral sympathectomy in dogs, employing a modification of the technic originally developed by Cannon and his associates[8] has been demonstrated to lower temporarily a normal dog's blood pressure, to eliminate the hypertension response to increased intracranial pressure, and to lower the blood pressure of neurogenic hypertensive dogs for a time to the vicinity of the normal. These and other experiments suggested that total paravertebral sympathectomy might accomplish more in clinical hypertension than splanchnic area denervation alone, especially if there should be an element of a neurogenic nature in clinical hypertension. The recovery of some degree of central vasomotor control following total sympathectomy in dogs, as previously reported[9] is incomplete. It does suggest, however, that the vascular alterations achieved by the operation in clinical hypertension might be limited in duration.

Studies related to experimental renal hypertension of the type developed by Goldblatt and his associates[10] have offered little encouragement to sympathetic surgery in clinical hypertension. This renal type of hypertension persists in the experimental animal after total paravertebral sympathectomy.[11, 12, 13, 14] This observation demonstrates that the vascular bed is under an influence, probably humoral, the action of which is independent of the sympathetic nervous system. If clinical hypertension were primarily renal in nature, the large splanchnic vascular area denervated by operation would also be under the same humoral vasocostrictor influence.

The possibility of improving the blood supply of the kidney and thus altering the formation of a renal pressor substance has been suggested by Peet.[4] Clinical studies of renal hemodynamics have, however, failed to show any consistent alteration following splanchnic area denervation in hypertensive patients (Foa, Woods, and Peet,[15] and Corcoran, personal communication).

The mechanism of hypertension in man is probably complex. It is generally accepted that it is mediated by an increase of the peripheral resistance offered by the vascular bed to blood flow. The extent to which processes comparable to experimental renal or experimental neurogenic hypertension may play a rôle in man in increasing the peripheral resistance has not been clearly demonstrated. Grollman, Williams, and Harrison,[16] Page, Helmer, Kohlstaedt, Fouts, Kempf and Corcoran,[17] and others, are developing tissue extracts which they report to be effective in lowering the blood pressure of renal hypertensive dogs and hypertensive patients. If these substances should prove to have specific action against the renal humoral mechanism, their use

in patients would contribute a great deal toward an understanding of the etiology and, possibly, also toward the control of clinical hypertension. Until their availability and ultimate utility are demonstrated, surgical efforts in the treatment of hypertension appear to be justified.

Total paravertebral sympathectomy might accomplish more than splanchnic area denervation in the treatment of hypertension in man especially if, as is stated above, there should be a component of a neurogenic nature in clinical hypertension. A technic has, therefore, been developed for total paravertebral sympathectomy. This procedure has been attempted on 11 patients with varying degrees of success.

Technic.—The operation, when carried to completion, is undertaken in three stages, two thoracic and one abdominal. At each thoracic operation, the stellate ganglion and the entire thoracic sympathetic ganglionated chain, the entire length of the splanchnic nerve and its minor branches, and the major portion of the celiac ganglion of that side is removed. An effort is also made, but without marked success, to obtain through the diaphragm the first or first and second lumbar ganglia. Figure 1 shows the sympathetic anatomy involved. The third stage, in those instances in which it is employed, consists of a bilateral excision of the remaining portions of the lumbar sympathetic chains down to or including the fifth lumbar ganglion. The operation is of necessity transthoracic and transabdominal. The thoracic stages were performed under ethylene anesthesia, using positive pressure through a face mask, and the abdominal operation under either spinal or ethylene-ether anesthesia. Long alligator forceps, dissectors, hooks and scissors both straight and curved have been devised for dissection of the nerve roots and branches. A special oval-headed, malleable retractor is used for the lungs and a heavy malleable roundheaded retractor with two small hooks at the end for retraction of the diaphragm (Fig. 2).

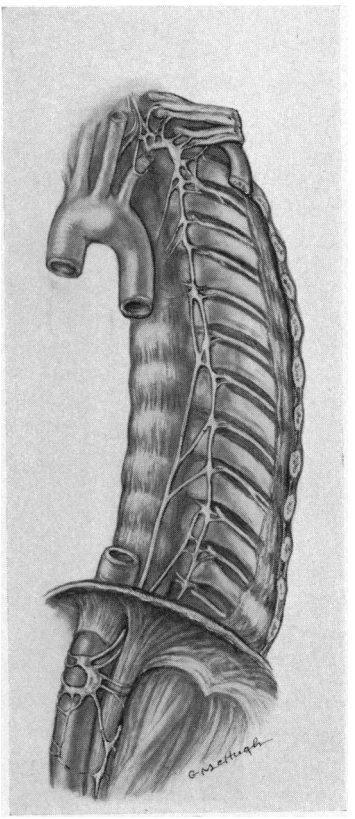


FIG. 1.—The relationships of the stellate ganglion, thoracic sympathetic chain, splanchnic nerves, celiac ganglion, and first portion of the lumbar sympathetic trunk. The proximity of the celiac ganglion and the diaphragm is illustrated.

Figure 3 illustrates the location of the incisions. The first incision is made in the axillary region over the third rib which is exposed and resected to the extent of about 12 cm. The thoracic cavity is entered through the rib bed. The lung is retracted, the sympathetic ganglionated trunk is located, and the pleura overlying its upper five segments is divided. Figure 4 represents the exposure

of the upper sympathetic chain and stellate ganglion. The connections of the upper thoracic chain and stellate ganglia are severed. The incision in the pleura is then extended over the sympathetic chain to the level of the eighth thoracic ganglia exposing the beginning of the splanchnic nerve. Figure 5 represents this portion of the exposure. The roots of the ganglionated trunk

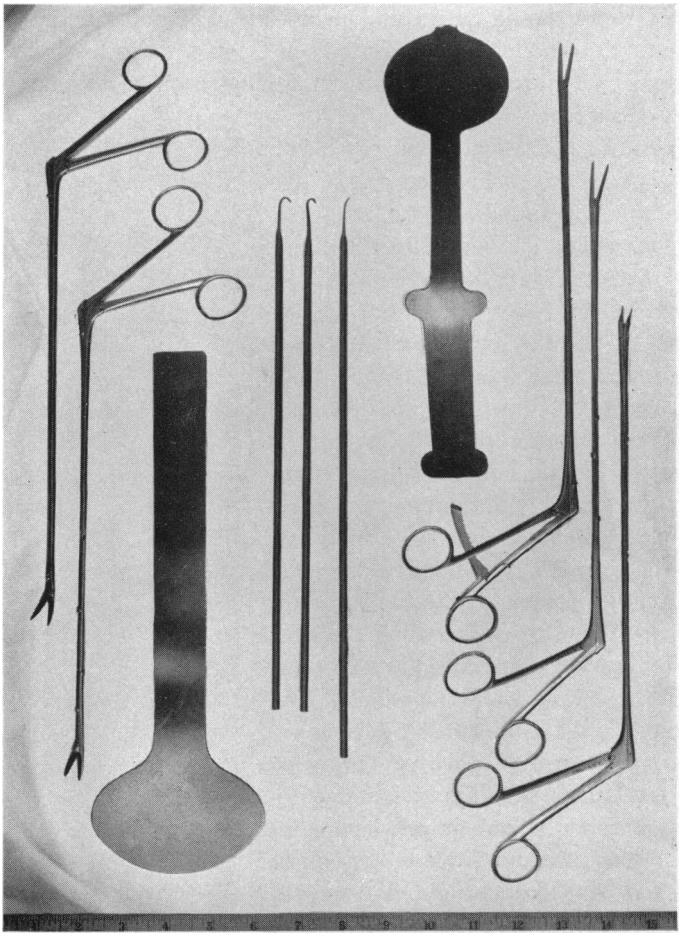


FIG. 2.—The special long alligator forceps; curved and straight scissors; dissector and hooks; oval-headed malleable lung retractor; and round-headed hooked diaphragm retractor used in the thoracic sympathectomy. The dissector is 12 inches in length.

are cut down to the eighth ganglion, the origin of the splanchnic nerve is freed, and the chain is dropped down into the lower thoracic cavity. The incision in the chest wall is closed.

A second lateral incision is then made over the course of the tenth rib and 12 to 14 cm. of its length is resected. The thoracic cavity is entered through the rib bed. The free end of the sympathetic chain is picked up and its remaining portion and the splanchnic nerve and its connections are dissected

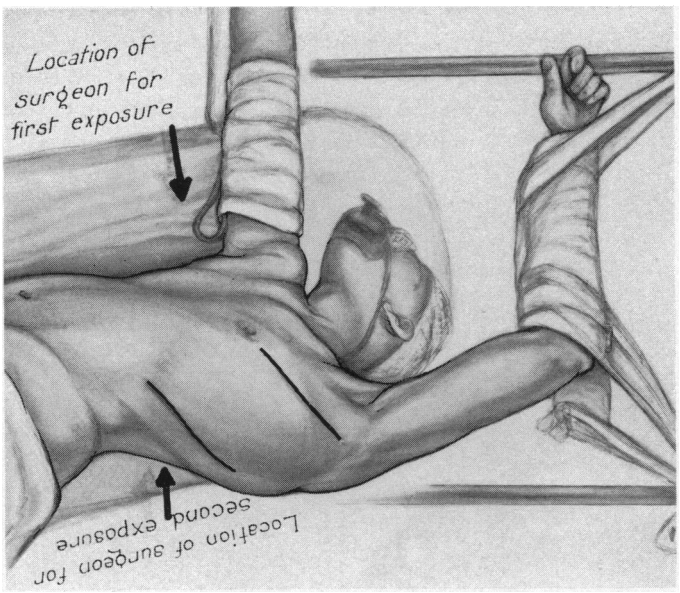


FIG. 3.—The position of the patient during the thoracic operation and the location of the two incisions used. The stellate and upper 8 sympathetic ganglia are dissected free through the upper incision and the remainder of the thoracic trunk, the splanchnic nerve, the celiac ganglion and, at times, the first or first and second lumbar ganglia are removed through the lower incision.

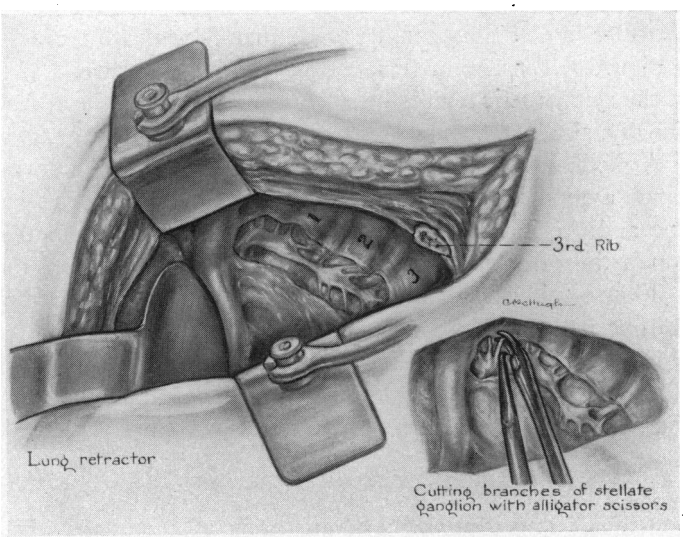


FIG. 4.—The stellate ganglion and the upper thoracic sympathetic trunk exposed through the incision in the bed of the third rib. The overlying pleura has been divided.

free down to the diaphragm. The pleura over the arch of the crux of the diaphragm is divided and the curved tip of the special round diaphragmatic retractor is placed in the arch. Strong retraction on this instrument partly inverts the diaphragm and allows the celiac ganglion to be pulled up through the diaphragm by traction on the splanchnic nerve after blunt separation of the adjacent diaphragmatic muscle. This ganglion is removed as completely

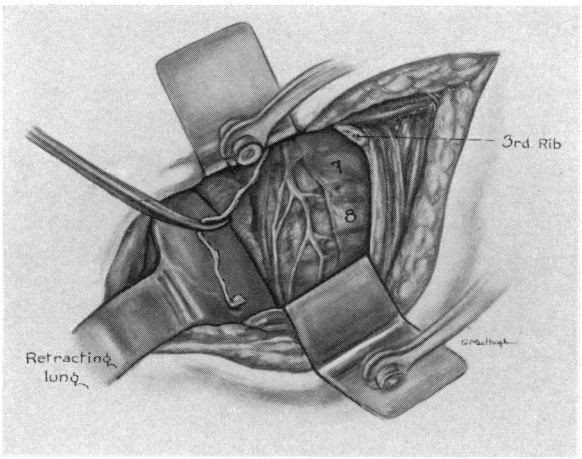


FIG. 5.—The origin of the splanchnic nerve at the lower end of the operative field, exposed by the incision through the third rib bed. The ganglionated sympathetic nerve trunk is freed through this incision down to D7 or D8.

as possible by dividing its distal connections. The sympathetic chain is then followed down through the crux of the diaphragm as far as possible and divided. Success in obtaining ganglia lower than the twelfth thoracic has been variable. Figure 6 represents this portion of the exposure. The thoracic portions of the sympathetic trunk, the splanchnic nerve and the celiac ganglion, and occasionally, also, the first or the first and second lumbar ganglia are thus removed. A medium-sized Pezzar catheter is then inserted into the pleural cavity through a stab wound between the seventh and eighth ribs in the mid-axillary line and the incision is closed. Air is evacuated from the thoracic cavity through the catheter and a negative pressure maintained for four or five days. Figure 7 illustrates a photograph of the specimens removed from the chest of one patient.

Of the 11 patients, eight had the thoracic procedures. One of these died after the first stage and one after the second. Three patients had both the thoracic and abdominal procedures. Brief case reports are presented.

ABBREVIATED CASE REPORTS

BILATERAL THORACIC OPERATIONS

Case 1.—J. W., female, single, age 18 at the time of operation. She had been observed to have a blood pressure of 176/124 three and one-half years earlier when seen in the Urology Clinic because of nocturia. Double ureter and kidney pelvis on the

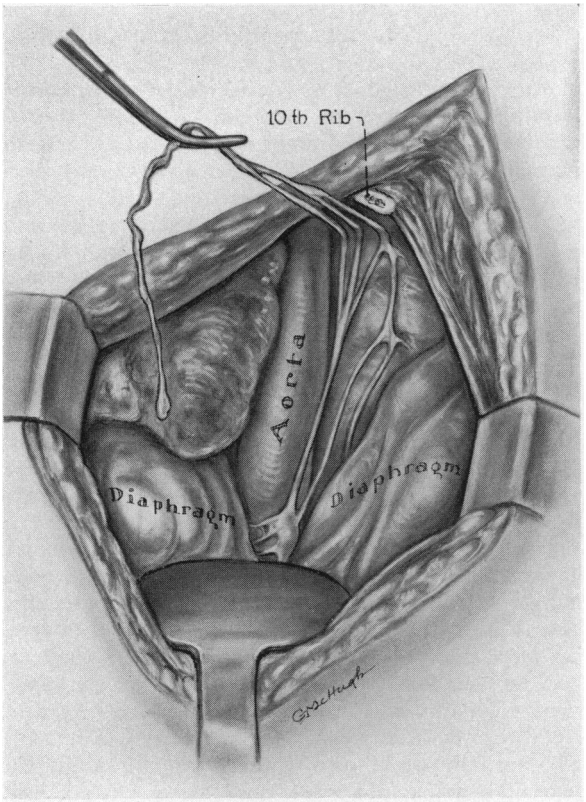


FIG. 6.—The exposure of the lower end of the thoracic sympathetic trunk and of the splanchnic nerves. The celiac ganglion has been pulled up through the diaphragm. It is removed, as are also as many of the lumbar ganglia as can be reached.

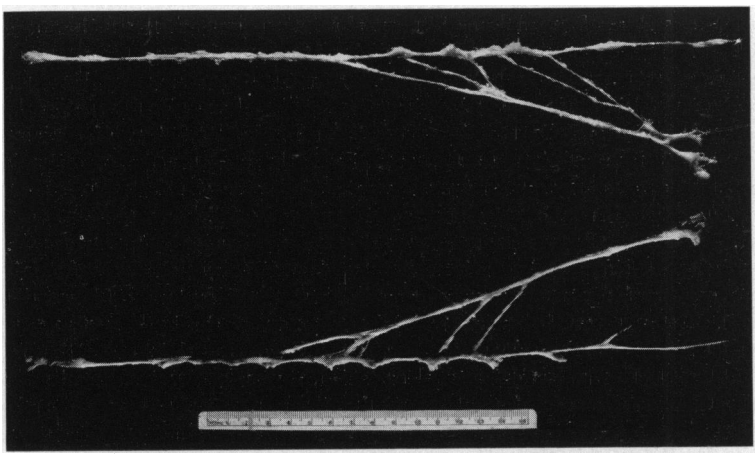


FIG. 7.—A photograph of the operative specimens removed from Case 10 during the bilateral thoracic operations. The stellate ganglia; splanchnic nerves; celiac ganglia; and, on one side, the first lumbar ganglion are shown.

right was observed. The patient had occasional periods of mild urinary infection and of albuminuria. The blood pressure rose gradually in spite of medical management and restricted activity until it ranged around 200/138. The patient complained of occasional severe headaches. Eyeground examination revealed generalized attenuation of the retinal arteries. There was a bilateral moderate exophthalmos. Rest and 0.6 Gm. of sodium amytal reduced the blood pressure from around 212/146 to around 170/120. The two stages of the bilateral thoracic paravertebral sympathectomy were carried out, with an interval of two weeks. The blood pressure between the two operations was as high or higher than before. After the second operation it fell, and three weeks later, at the time of discharge, ranged around 146/98 when the patient was supine. She has been observed seven months and two weeks following the procedure, and her last blood pressures are around 140/90 when supine and 104/70 when standing. Dizziness on standing was noticed during the first month after operation. The patient is now active with no complaints.

Case 2.—R. B., female, married, age 25 at the time of operation. She gave a history of nephritis, with blood and albumen in the urine between the ages of four and five. Three and one-half years before operation she developed headaches. Three years before operation she became pregnant and a blood pressure ranging around 180/110 was observed together with albumen and blood in the urine. A therapeutic abortion and sterilization were performed. Six months later the headaches became more severe and a blood pressure of 220/120 was recorded. Under medical management during the next two and one-half years, her blood pressure was observed to range around 180/110. In the hospital during the week before operation, it averaged 168/104. During this period of three years, there was no significant finding in the urine. With rest and 0.6 Gm. of sodium amytal her blood pressure dropped from 180/108 to around 140/90. The cold pressor test showed an elevation of 35 Mm.Hg. systolic and 30 Mm. diastolic. Eyeground examination revealed increased tortuosity of the retinal arteries. After the first stage, there was no change in blood pressure but after the second, there was a lowering to around 106/64 during a six weeks' postoperative period of observation. She has now been observed 14 months, during which her blood pressure has ranged around 120/70 supine and 100/64 standing. The patient is active with no complaints.

Case 3.—C. D., female, married, age 33 at the time of operation. Eleven and one-half years earlier, during a premature delivery, her systolic blood pressure was recorded at 220 Mm.Hg. After delivery, her systolic blood pressure varied from 180 to 220. One year and seven months before operation, she went through an episode of precordial pain, dyspnea, and swollen ankles. Six months before operation, she had a cerebral accident involving the right arm and leg and leaving extensive residual paralysis. Her blood pressure on admission was 242/148. During two weeks in the hospital, before operation it ranged between 286/170 and 200/120. The elevation with the cold pressor test was 20 Mm.Hg. systolic and diastolic. With rest and 0.6 Gm. of sodium amytal the pressure fell from 260/160 to 220/145. Papilledema, hemorrhage, exudation, and other advanced eyeground changes were present. Following the first thoracic operation, there was no reduction in blood pressure. Immediately following the second thoracic operation, the blood pressure ranged around 140/80. The patient, however, did not regain consciousness and 30 hours later developed respiratory failure. Artificial respiration was continued for several hours after which time circulatory failure developed, with death. Autopsy revealed a cavity in the left side of the brain 2.5 x 1.5 x 6.5 cm. in length running from the central white matter of the frontal lobe posteriorly to the caudal extremity of the lenticular nucleus. There was generalized cerebral arteriosclerosis with old and recent foci of encephalomalacia and old and recent perivascular hemorrhages in the pons. It is of interest that during the 30-hour postoperative period of reduced blood pressure, the patient excreted 1,600 cc. of urine.

Case 4.—I. M., married, female, age 38 at the time of operation, and had only one preoperative complaint, that of blurring vision requiring frequent changes in her glasses.

Six months before operation her blood pressure was 220/120. Between then and the date of operation, it ranged around 210/118. In the hospital, the week before operation it averaged 180/114. Eyeground examination revealed only generalized attenuation of the retinal arteries. Rest and sodium amytal lowered the blood pressure from around 180/110 to around 135/90. The cold pressor test elevated the systolic pressure 35 Mm.Hg. and the diastolic 25 Mm. The two-stage thoracic procedure was carried out. During the 17-day interval between operations, no lowering of blood pressure was observed. It ranged around 150/102 during the four weeks in the hospital after operation. This patient developed a mixed psychoneurosis with secondary depressions. She fixed on the operation as the cause of all of her troubles. Hospitalization was carried out one and one-half, two, and four and one-half months postoperatively because of this psychiatric difficulty. Her blood pressure during these hospitalizations averaged 166/96, 144/96, and 150/100, respectively. She has since been more antagonistic, and one reading, seven and one-half months after operation, was 198/128 lying and 184/104 standing. The last blood pressure readings, 12 months after operation, were 144/102 lying and 112/84 standing.

Case 5.—E. R., a poorly nourished male, age 40 at the time of operation. He had consulted a physician four and one-half years earlier because of lack of appetite, dizzy spells, and headaches. His blood pressure then varied between 170/130 and 145/90. It gradually rose, and during the three and one-half years before operation ranged from 206/130 to 176/116. Fatigue, headaches, and dizziness persisted. One year before operation, he had a mild cerebral accident following which he could no longer perform his duties as a lathe operator. During the week before operation, his blood pressure averaged 178/116. Rest and 0.6 Gm. of sodium amytal lowered his blood pressure from 194/120 to around 165/105. The cold pressor test elevated it 24 Mm.Hg. systolic and 10 Mm. diastolic. Examination of the eye revealed irregularity and marked narrowing of the retinal vessels and some arteriovenous nicking. The two stages of the thoracic operation were performed 13 days apart, with no blood pressure lowering between. Sixteen days later the patient was discharged. The postoperative hospital blood pressure readings averaged 126/86. During eight months of postoperative observation the blood pressure ranged around 140/100 supine and 96/74 standing. He has occasionally had mild headaches but the fatigue and poor appetite persist and he considers himself unable to work.

Case 6.—H. S., male, age 42 at the time of operation. A year and one-half earlier headaches developed and eight months ago his blood pressure was 190 systolic. Six months before operation a cerebral accident occurred involving the right arm, leg, and face and making speech difficult. The blood pressure was 255/145. A month later recovery of the use of the leg began and he was able to walk. There was limited use of his arm at the time he entered the hospital. His blood pressure in the hospital before operation averaged 196/128. Sodium amytal lowered it from around 230/134 to around 160/120. The cold pressor test elevation was 70 Mm.Hg. systolic and 60 Mm. diastolic. Eyeground changes consisted chiefly of constriction of the retinal arteries with tortuosity of the smaller vessels. The patient received the thoracic operations with an interval of 14 days, during which there was no change of blood pressure. He then remained in the hospital six weeks during which time his blood pressure ranged around 146/90. He has been followed postoperatively for eight and one-half months and during that time has had a blood pressure ranging around 150/94 lying and 124/84 standing. He has now no complaints and is active although unemployed.

Case 7.—R. E., male, age 48 when operated upon. Four years before his blood pressure was reported to have been around 210/135. His complaints were chiefly fatigue, dyspnea after climbing one flight of stairs, and disturbance of vision. Eleven months before operation, hemorrhage and exudation were noted in the eyegrounds. Six weeks before operation his blood pressure was as high as 272/172. Papilledema, with marked progression of the hemorrhages and exudates, were noted. In the hospital before operation, the blood pressure ranged around 235/158. Rest and 0.6 Gm. of

sodium amytal lowered it from around 210/140 to around 185/120. The cold pressor test gave an elevation of 50 Mm.Hg. systolic and 45 Mm. diastolic. Right thoracic sympathectomy was performed. There was, as in the other patients, no lowering of blood pressure following this procedure. Sixteen days later a roentgenogram of the chest revealed the lungs to be clear; and the patient was sitting up out of bed. The second-stage operation was under consideration when he developed pneumonia followed by uremia, and, 21 days later, by death.

Case 8.—L. F. M., male, age 50 at the time of operation. Four years earlier he developed severe headaches and noticed occasional dizzy spells. During the last two years, these symptoms became more severe and the systolic blood pressure was over 200. Four months before operation, a cerebral accident occurred with a paralysis of the left arm and leg from which there has since been extensive recovery. The blood pressure was 252/140. During the week in the hospital before operation, it averaged 218/130. Rest and 0.6 Gm. of sodium amytal reduced the blood pressure from 228/120 to around 188/100, with two single readings of 166/88 and 150/90. The cold pressor test produced an elevation of 50 Mm.Hg. systolic and 30 Mm. diastolic. Eyeground examination revealed a thickened, slightly blurred nasal nerve fiber layer on the right disk and nicking, hemorrhage and exudation in the retina. Urea clearance determinations were at the lower limits of normal. Following the right thoracic sympathectomy, cardiac decompensation and pulmonary edema developed. These complications cleared up in about two weeks. No blood pressure lowering was observed in the 25-day interval that preceded the second stage. Cardiac and pulmonary complications were also observed after the second stage. During the next five weeks in the hospital, his blood pressure ranged around 156/90 supine. Seven months after operation, he was admitted to the hospital for two weeks during which time his blood pressure readings averaged 160/90. His readings in the out-patient department have been higher, ranging around 172/100 supine and 134/104 standing 12 months postoperatively. This patient while having less energy than formerly has no special complaints and is active.

BILATERAL THORACIC AND ABDOMINAL OPERATIONS

Case 9.—A. W., female, married, age 33 at the time of operation. Five and one-half years earlier she developed albuminuria and a systolic blood pressure of 290 in the fourth month of pregnancy. A therapeutic abortion was performed. During the next two years, the patient had several attacks of precordial pain. The blood pressure elevation continued. Dyspnea, palpitation, and ankle swelling had gradually progressed. She was first seen here at that time, and the blood pressure was 240/144. Eyeground examination showed the disks to be pale with hazy margins and tortuous capillaries on their surfaces. Arteriovenous compression, small hemorrhages, and exudates were observed in the retinae. Rest and 0.6 Gm. of sodium amytal lowered her blood pressure from 230/128 to 204/118. Cold pressor tests produced an elevation of 20 Mm.Hg. systolic and 30 Mm. diastolic. Thiocyanate therapy was employed for four months, with the blood pressure unchanged, averaging around 230/130. A bilateral supradiaphragmatic splanchnic area denervation, as advocated by Peet,[4] was then carried out by Dr. William Adams. The blood pressure averaged 190/122 for one week and then returned to its previous level. Three months later, thiocyanate therapy was again employed without appreciable effect. Fifteen months later, an attempt was made to complete the sympathectomy using the technic described above. All three stages were employed at one-month intervals. Following each stage, there was some lowering of pressure until after the abdominal operation it averaged for two weeks 174/108. It then gradually rose until at two months it reached an average supine of 220/130. She has been observed 11 months. The last blood pressure reading is 254/154 supine and 192/120 standing. The patient is moderately active with only occasional mild headaches. Swelling of the ankles is again evident.

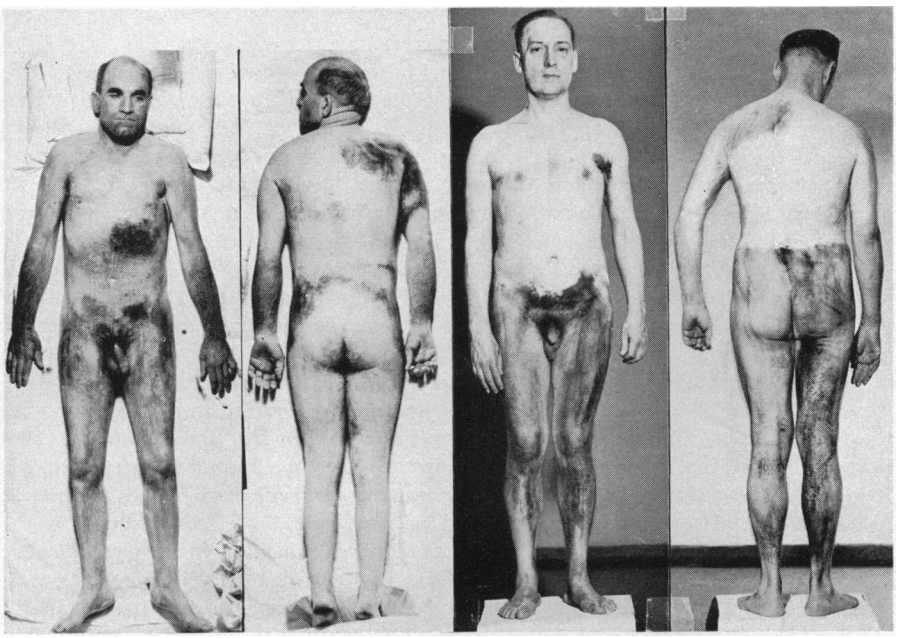
Case 10.—L. M., widow, age 40 at the time of operation, and had had headaches for about four years. She suffers from a severe anxiety neurosis that has persisted up to the present time, with only slight improvement. The first blood pressure readings a year and eight months before operation were 248/128 and 280/130. She was hospitalized four weeks at that time, and the blood pressure readings averaged 236/128. Thiocyanate therapy was without evident effect. The blood pressure continued for a year and six months around 250/134 with one high reading of 310/144. During four weeks of hospitalization preceding operation, there was some improvement in the mental state and the average blood pressure was 204/110. Eyeground examination revealed minimal hemorrhage and exudate and marked nicking but no papilledema. Rest and 0.6 Gm. of sodium amytal lowered the blood pressure from around 240/120 to around 160/90. The cold pressor elevation was around 35 Mm.Hg. systolic and 20 Mm. diastolic. The blood pressure during the 12-day interval between the thoracic stages was unchanged. Following the second stage it ranged around 180/96 for two months. The abdominal sympathectomy was then performed. The blood pressure during the next three weeks ranged about the same level. Four months later a single reading was 280/154. The patient was readmitted to the hospital for a week and the blood pressure averaged 192/108. Her latest blood pressure readings, 10 months after the third stage, range around 224/124 supine and 160/90 standing. She is active, and states that she feels better.

Case 11.—McK. T., male, age 44 at the time of operation. The blood pressure is known to have been elevated for seven years, starting around 180/110 and gradually increasing to around 210/130. The complaints were occasional headaches and attacks of numbness usually unilateral, involving the arms and legs. Eyeground examination revealed early edema of the disks with marked perivascular sheathing of the retinal vessels. Rest and 0.6 Gm. of sodium amytal lowered his pressure from around 200/112 to around 158/90. The cold pressor response was 40 Mm.Hg. systolic and 70 Mm. diastolic. Because of the possibility of an adrenal tumor, the abdominal sympathectomy including division of most of the splanchnic nerves was performed first. Exploration of the adrenal glands and kidneys revealed no gross pathology. Following this, the blood pressure ranged around 158/108 for 20 days, at which time the right thoracic sympathectomy was performed. In the 23 days that preceded the left thoracic sympathectomy, the blood pressure was around 150/102. Following this, it ranged around 128/80 for eight weeks. All of these readings were taken with the patient supine. The patient had a marked postural hypotension, with extreme dizziness, and it was six weeks after the last operation before he could walk about and be discharged. It is too early to evaluate the symptomatic change. Six months after operation his blood pressure readings were 140/100 supine and 76/54 standing.

SUMMARY.—A three-stage technic for removal of the thoracic and lumbar paravertebral sympathetic chains including the stellate ganglia, splanchnic nerves, and the major portion of the celiac ganglia has been described. This operative procedure has been employed upon 11 hypertensive patients. Three had only slight organic hypertensive changes, four had had cerebral accidents, three were old, severe long-standing hypertensions, and one was a rapidly progressing severe hypertension with renal deficiency. Two of these patients, one with marked brain damage, and one with marked renal damage, died. The bilateral thoracic procedure only was employed in six patients and the three-stage procedure including the lumbar sympathectomy was employed in the remaining three. A complete loss of sweating has not been achieved. The iodine, starch, heat-sweating test has shown occasional patchy areas of sweating

in the apparently denervated areas in each patient. Figure 8 shows the dark areas of sweating in Case 11 after the three-stage procedure, and in Case 6 after the two-stage thoracic procedure.

This extensive sympathectomy has been demonstrated to be compatible with a relatively normal existence. The patients dress more warmly in cold weather and notice excess perspiration during warm weather in those areas still capable of sweating. Dizziness associated with postural hypotension has



CASE 11. CASE 6.

FIG. 8.—The dark areas of sweating visualized by the iodine, starch, and heat test in Case 11, after the three-stage sympathectomy; and, in Case 6, after the bilateral thoracic procedure. Areas of sweating are present in the regions supplied by the sympathetic trunks that have apparently been removed.

been troublesome only during the first few months. The bilateral Horner's syndrome has been distressing to only one patient, Case 4. A transient hyperactivity of the bowel has been noticed after each thoracic procedure in many of the patients. The pulse rate has been somewhat decreased. The response to stimuli such as the cold pressor test has been either unchanged or slightly diminished. The blood pressure lowering response to rest and sedation as in the sodium amytal test has been in most instances almost entirely abolished (Chart 1).

Some lowering of blood pressure has been observed on each patient. The lowerings of the blood pressure with the patient supine have varied from a transient one followed by a restoration to about the previous hypertensive level in Case 9, to a lowering to relatively normal values over a period of 14 months of observation in Case 2. The lowering of blood pressure with the

patient standing, sitting, or walking about has been more marked and is present in all patients. The patients have been followed from six to 14 months. No blood pressure lowering was observed after the first thoracic operation in nine patients. This serves as somewhat of a control for nonspecific blood pressure lowering operative effects. The observed blood pressure lowerings seem to be related to the extensive removal of the sympathetic system.

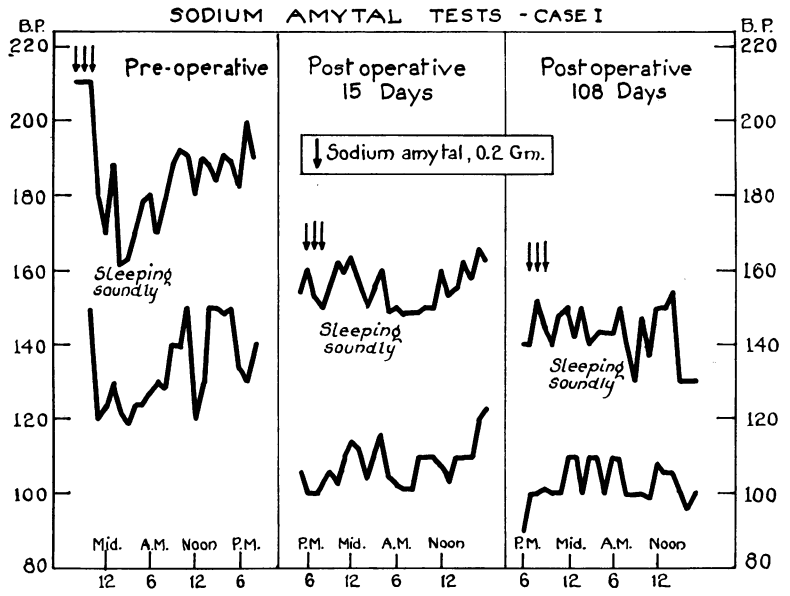


CHART 1.—Showing the effect of rest and 0.6 Gm. of sodium amytal during the 24-hour test periods on the blood pressure of Case 1, before the bilateral thoracic operation, and 18 and 108 days after this procedure. The general blood pressure level is lower. The sodium amytal test after operation produced no additional lowering.

Doctors Alving, Wright Adams, and others[18] have conducted extensive cardiorenal studies on many of these patients before and after operation. They have found no regular significant change in the urea clearance, the ability of the kidney to concentrate urine, venous pressure, or arm-to-tongue circulation time. The heart rate and cardiac output under basal conditions was decreased slightly. Studies of renal blood flow, glomerular filtration rate, and functioning tubular mass have shown no significant change. Renal blood flow increased in one patient and was either unchanged or decreased in the others. They conclude that such lowering of blood pressure as occurs after this extensive sympathectomy is due to a decrease in peripheral resistance. It is impossible at the present time to correlate this alteration of peripheral resistance to any alteration of possible etiologic factors in these patients that might parallel either experimental neurogenic or renal types of hypertension. The rôle that either or both of these factors, together with organic vascular pathologic changes increasing the peripheral resistance may play in clinical hypertension awaits further clarification.

CONCLUSIONS

This is a report of studies in progress of the effect of extensive to total paravertebral sympathectomy in hypertension and no conclusions are drawn as to whether or not this operative procedure will prove to be one of lasting merit. It is a more extensive operation and carries a greater risk than does splanchnicectomy but it appears to lower the blood pressure more consistently. The results are sufficiently encouraging to warrant further studies of the cases already operated upon and further operative trial in selected cases.

The author wishes to acknowledge his appreciation for the cooperation and aid given by Drs. Alf S. Alving, Wright Adams, Jerome Gans, Louis Leiter, Richard Sternheimer, Alf Haerem and others, of the Department of Medicine who have cooperated in the study and management of these patients.

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DISCUSSION.—DR. R. H. SMITHWICK (Boston, Mass.): We have approached this problem from a rather different viewpoint than that which has been presented this evening. Our experience has been entirely confined to a study of hypertension in man. We have felt that hypertension in man, in itself, is a highly experimental and a very complicated problem. There appear to be a number of variable factors which combine to result in hypertension in man. I think there is one thing that we will all agree upon, and that is that nobody knows the cause of hypertension in man.

For this reason, we have felt that the best method of procedure was to start with the simplest operation that we thought might result in reduction of blood pressure. Because of the upright position of man, we have felt that the splanchnic bed must be much more highly developed, in order to maintain blood pressure relatively normal in the various positions than is the case with the dog. Therefore, we thought that it would be advisable, following the lead of Adson and Peet, to denervate the splanchnic bed and to see what the results of that procedure were and, if we found evidence from our studies that further surgery was indicated, to proceed on the basis of evidence derived from our studies in man, rather than from evidence deduced from experimental work.

A chart was shown by the speaker which represented what he considered a good result from partial denervation of the splanchnic bed. Our criterion for partial denervation of the splanchnic bed is that there is no significant change in blood pressure as the patient changes position. Our criterion for complete denervation of the splanchnic bed is a striking and precipitous fall in blood pressure as man shifts from the horizontal to the vertical position.

This patient is characteristic of the good results that we obtained, in a series of approximately 70 cases followed up to four years, by partial denervation of the splanchnic bed by one method or another. This happens to be the result of a supradiaphragmatic splanchnicectomy by the Peet technic. The patient is in the early stage of the disease, is very young, and fulfills all the qualifications that we know of that would indicate a good result. Her blood pressure has been within normal limits, except for possibly slight diastolic hypertension, for approximately four years. One might wonder what further effect there would be if this patient were totally sympathectomized. Our feeling has been, and we have been interested in the question of more extensive sympathectomy for a number of years, that faced with a result like this, in our present stage of ignorance concerning this disease, we were not justified in proceeding with further denervation.

In these 70 cases of partial denervation of the splanchnic bed, our medical department came to the conclusion that nine and one-tenth per cent had results comparable to this; that is, unquestioned persistent and significant lowering of blood pressure. That figure is considerably lower than has been reported by others, with much greater experience.

Some patients do not respond to partial denervation of the splanchnic bed, and in these, we wondered whether further denervation, more extensive sympathectomy, might be helpful. A chart was here shown of a patient who was one of a number of failures of partial sympathectomy, and decided to proceed further. First of all, before any surgery, she was followed in the out-patient department for several months, and while under observation developed an hemiplegia. She recovered from that satisfactorily, was followed several months more, and we decided to operate. She had a supradiaphragmatic splanchnicectomy in two stages, again the Peet technic. We felt there was no significant blood pressure response following the operation.

We decided to proceed further. I might say that in other cases before this, instead

of proceeding downward, as we did in this case, we proceeded upward, in order to increase the magnitude of the operation to include the lower half of both thoracic sympathetic chains, not including the heart. In no case who had failed to respond to the Peet operation did we get any significant response by proceeding higher in the thorax. On the other hand, by proceeding downward, we did, in a number of cases, observe a significant response. In other words, by adding bilateral lumbar sympathectomy in two stages we derived a significant response. Thus, in addition to the Peet operation, the first, second, and third lumbar ganglia were removed on both sides.

So we came, after a period of trial and error, to feel that complete splanchnicectomy, which resulted in postural hypotension in every case, might offer more for some of these individuals, and this was accomplished by removing the sympathetic trunks from D_9 to L_1 or L_2, inclusive, both sides, together with excision of the great splanchnic nerves from the semilunar ganglia to about the midthoracic level.

A chart was here shown demonstrating a typical good result from this procedure, showing a reduction of blood pressure to normal for two years in a patient with malignant hypertension.

We also wondered whether in patients who did not respond to the combined supra- and intradiaphragmatic operation further sympathectomy would be beneficial. A chart was here shown of a patient who had been sympathectomized totally. This was undertaken in seven stages, and we felt there was no significant response.

Our impression is that in patients who do not respond to complete splanchnicectomy, further denervation probably will not result in significant lowering of blood pressure. On the other hand, we feel that in those who do respond to complete splanchnicectomy, we are not justified in proceeding with further sympathectomy in the present state of our knowledge. Such indications may arise in time, but it is our notion that they had best be deduced from the study of hypertensive patients rather than from experimental animals.

Our percentage of significant and persistent lowering of blood pressure following complete splanchnicectomy, as contrasted with partial splanchnicectomy, is as 65 per cent is to 9.1 per cent, at the present time.

In commenting upon the paper this evening, I think we have been presented with a very detailed and valuable study in a small series of patients. It is difficult to compare this statistically at this time with other larger series. However, I think that Doctors Grimson and Phemister are to be congratulated on the care and the detail with which they have studied their cases. I think that time alone will tell whether total sympathectomy has anything more to offer these patients than less than total sympathectomy.

DR. GEORGE M. CURTIS (Columbus, Ohio): From carefully controlled clinical studies such as these, and particularly from those which have grown out of previous laboratory experimentation, much clinical physiology may be learned in evaluating the effects of the application of newer operative procedures. Thus the application of pneumonectomy to the treatment of lung carcinoma has led to the operating table demonstration of the low blood pressure normally present in the pulmonary artery.

In sympathectomy combined with ganglionectomy in the treatment of hypertension, we are thinking mainly of vasomotor effect, although secretory effects, and particularly those from the adrenal, have received due consideration. Nevertheless, other visceral mechanisms are also involved when the lower thoracic sympathetic chain and splanchnic nerves are removed. Thus, there is an ensuing increased motor activity of the stomach, perhaps due to the then unopposed action of the vagi (Arch. Surg., **32**, 577, 1936).

However, we should be careful not to lose sight of the sensory fibers from the upper abdominal viscera. Some of these pass upward through the splanchnic nerves, along the ganglionated cord and through the white rami to the dorsal ganglia and spinal cord. In this surgical field, opportunity is thus afforded to learn something of the sensory impulses they carry. It may be that they act in an important manner in the sensory defense of the upper abdomen.

Thus a number of clinical symptoms are closely associated with hypermotility of the human stomach. Among these may be mentioned nausea, upper abdominal distress, or cramps, and certain types of "gas pains." Moreover, hypermotility may be induced by morphine with the production of upper abdominal distress and then controlled, together with the discomfort, by atropine.

Yet in the hypermotility subsequent to bilateral splanchnic resection, our few patients have not noted these accompanying disturbing sensations, such as would ordinarily accompany such evidence of increased gastric activity. Is it possible that excision of the splanchnic nerves has also removed an important sensory mechanism in the interpretation of visceral change in the upper abdomen? The answer to this question obviously has a practical clinical bearing and merits further clinical attention. Perhaps the speaker may also have a solution to the problem.

Our own consideration of the matter may be presented by showing a few charts:

Chart 1 shows the method which we have used for studying the motor activity of the human stomach following unilateral and bilateral splanchnic resection. The ink writer here obviates the smoked drum and makes this work possible in the clinic along with the white linen.

This is a roentgenogram showing the position of the balloon in the stomach, connecting through this tube to the kymograph.

Chart 2 is that of a patient, with an obstructive duodenal ulcer, showing a marked increase in gastric motility, and with it was associated severe abdominal pain. Later, ensued a spontaneous remission of the increased motility with cessation of the upper abdominal distress.

Chart 3 is that of a patient who had, postoperatively, what are commonly called "gas pains" or cramps, and as these occurred he pressed a button, recording these simultaneously with increases in peristaltic action of the stomach. Atropine intravenously, 1/150 gr., at this point was given, with cessation of the distress and the associated increased contractions.

Chart 4 is that of patient with duodenal ulcer, to whom morphine, 1/8 grain intravenously, was given at this point. Note the ensuing increased activity, both in frequency and amplitude. This was accompanied by definite upper abdominal distress. After giving atropine, 1/150 gr., intravenously, there ensued cessation of the increased motility and disturbed sensation. Then prostigmine 1 to 2,000 was given at this point, which reversed the atropine effect and induced motility again. This increased in amplitude and frequency and its occurrence was accompanied by pain. Ephedrine at this point decreased the motility with an accompanying disappearance of the uncomfortable sensation. Thus, we would think that associated with gastric hypermotility there is usually abdominal pain or distress or discomfort (Trans. West. Surg. Assn., pp. 447–475, 1938).

Chart 5 is that of a patient who had previously had a resection of the left splanchnic nerves and later of the right splanchnic nerves. This operation, after the technic of Peet, was undertaken in two stages. Subsequent to this, there occurred a marked and persistent hypermotility of the stomach. You see here the increase in amplitude and frequency, which lasted for five hours. We have seen this increased activity persist for a period of six hours, with no complaint of discomfort or of other sensations ordinarily associated with hypermotility, whether occurring spontaneously or induced by morphine. This is another curve made from this same patient. Note the increase in amplitude of the peristaltic waves. Yet this patient did not complain of upper abdominal distress at that time (Am. Jour. Physiol., **120**, 356, 1937).

Chart 6 is that of a patient in whom a bilateral splanchnic resection was performed, according to the Peet technic. You see ensuing increased gastric motility. Yet with this hypermotility there was likewise no upper abdominal distress.

Thus, it would appear that the splanchnic nerves carry certain visceral sensations to the central nervous system, and that these are interrupted and, consequently, not interpreted following bilateral splanchnic resection. The clinical import is obvious, and further consideration seems warranted.

DR. MAX M. PEET (Ann Arbor, Mich.): I believe that we ought to study our hypertension patients, both before and after operation, from every standpoint, not just blood pressure. We ought to know the changes in the retina, the changes in the kidney, and in the heart. So we have studied all our patients from every possible standpoint. We have felt, as the others have, that the work is still experimental in many ways, and we could best determine its actual value by using one particular surgical procedure. We have operated upon some 700 patients now, using a bilateral supradiaphragmatic splanchnicectomy with the resection of a long segment of the greater splanchnic nerve and excision of the tenth, eleventh, and twelfth thoracic sympathetic ganglia. Often when pulling up on the greater splanchnic, we actually see the top of the celiac ganglion.

The excised portion of the greater splanchnic nerve extends from the eighth or ninth vertebrae to the diaphragm and measures, after removal, 10 to 15 cm. in length. Excision of such a long segment probably prevents regeneration. Occasionally, the ninth thoracic ganglion is readily exposed and when this occurs it is removed with the tenth and eleventh. Sometimes, the twelfth is deeply imbedded in the diaphragm, making its excision impossible. Under such circumstances, we have always cut the twelfth ramus, even though the exposure of this ramus required rather extensive division of the vertebral attachments of the diaphragm.

To rule out possible differences in individual technic, all the patients included in our very thorough follow-up studies were operated upon by me. All have been studied preoperatively and again at a minimal postoperative period of at least nine months by the medical, cardiac, ophthalmologic, and roentgenologic departments of the University Hospital. Pre- and postoperative studies included blood nonprotein nitrogen, water concentration, and urea clearance determination, electrocardiograms, orthodiagrams, and teleoroentgenograms, funduscopic examinations, and numerous blood pressure readings from both arms.

Only by such a thorough study can we evaluate any therapeutic procedure. Many of our patients have been studied repeatedly for several years. The longest postoperative period studied in any one patient, a man who before operation had a severe malignant hypertension, is seven years.

I submit the following tables from a paper on the Surgical Treatment of Hypertension, by Peet, Woods, and Braden (J.A.M.A., 115, 1875-85, November 30, 1940), to show you some of the results of bilateral supradiaphragmatic splanchnicetomy. I believe these are as good as those obtained by the much more formidable procedure of total or subtotal sympathectomy. The latter cannot as yet be definitely evaluated since the series is small, complete studies have not been made, and too short a postoperative period has elapsed:

TABLE I

BLOOD PRESSURE

	Number	Per Cent
Cases studied nine mos. or later postoperatively (including deaths)	290	100
Reduced (more than 40 Mm. systolic and 15 Mm. diastolic)	149	51.4
Unchanged	134	46.2
Increased (more than 10 Mm. systolic and 5 Mm. diastolic)	7	2.4
Cases with no data or dead before nine mos. postoperatively	60	

If the 60 patients concerning whom no data were obtained or who died before nine mos. are considered as unchanged or worse, the percentage of patients with significantly reduced blood pressure in the whole group of 350 cases becomes 42.6.

Table I shows the results of splanchnicectomy in a series of 290 patients followed from nine months to seven years. We have not considered any patient under nine months. You notice that of 290 consecutive patients 149, or 51.4 per cent, have had a reduction in blood pressure of more than 40 Mm. systolic and 15 Mm. diastolic; 46 per cent were unchanged. It is possible that some of the latter might be improved further by either a higher thoracic or a lumbar ganglionectomy. Only 2 per cent have increased here.

TABLE II

ANALYSIS OF PATIENTS WITH SIGNIFICANTLY REDUCED BLOOD PRESSURE

	Number	Per Cent
Number of cases studied	149	100
Reduced to normal	56	37.5
(130/90 for ages 20 to 40)		
(150/100 for ages 40 to 70)		
Markedly reduced (but not to normal)	15	10.1
(More than 80 Mm. systolic and 25 Mm. diastolic)		
Reduced (but not markedly or to normal)	78	52.4
(More than 40 Mm. systolic and 15 Mm. diastolic)		

Thus, of those cases in which there was significantly reduced blood pressure 47.6 per cent were reduced to normal, markedly reduced or both.

Of the 149 cases that showed worth while reduction, 37 per cent have had reductions to what our medical department considered normal. In other words, these patients

have had a normal blood pressure at a postoperative period from nine months to seven years. Certainly this group of patients, representing 37 per cent of those with a significant reduction in blood pressure, did not need a more extensive sympathectomy.

The blood pressure was considered as markedly reduced but not necessarily to normal, if the reduction was more than 80 Mm. systolic and 25 Mm. diastolic. These constitute 10 per cent. Those reduced more than 40 Mm. systolic and 15 Mm. diastolic but not markedly or to normal, constitute the remaining 52 per cent. It is significant that nearly half of those with a reduction in blood pressure had such a striking result as to be classed as either markedly reduced or reduced to normal.

I might remark that all the preoperative readings were made while the patient was quiet, usually in bed, while the postoperative readings were made while the patient was active and going through various tests. There is no postural change in blood pressure after supradiaphragmatic splanchnicectomy and resection of the lower thoracic sympathetic chain.

As stated before, we not only study the blood pressure but also the eye changes, cardiac condition, renal function, symptomatology, and ability to work.

TABLE III

SUMMARY OF RESULTS OF SPLANCHNICECTOMY: PERCENTAGE OF CASES STUDIED SHOWING IMPROVEMENT (FROM NINE MONTHS TO SEVEN YEARS AFTER OPERATION)*

	Per Cent
Blood pressure	
Reduced to normal	11.7
Markedly reduced (but not to normal)	7.6
Total cases significantly reduced	51.4
General disability	
Symptoms improved	86.6
Complete recovery incapacitation	55.5
Total cases with improvement incapacitation	81.3
Eyegrounds	
Disappearance of papilledema, when present	73.8
Total cases with improvement	69.4
Heart	
Heart size diminished	64
Electrocardiogram improved	53.4
Renal function	
Urea clearance improved	52.2
Urine concentration improved	44.8

* Statistics include those patients who showed improvement but who subsequently died.

Table III shows a summary of 350 consecutive hypertensive patients treated by bilateral supradiaphragmatic splanchnicectomy and lower dorsal sympathetic ganglionectomy. Fifty-one per cent had a worth while reduction in blood pressure. Symptoms were improved in 86 per cent. Papilledema was absent in 73 per cent of those who had choked disks before operation. Heart size was diminished in 64 per cent. The kidney function was improved as follows: Water concentration, 44.8 per cent; urea clearance, 52 per cent. Complete recovery from incapacitation occurred in over 55 per cent.

If we are going to evaluate any procedure for the treatment of hypertension, we must show not only improvement in blood pressure but improvement in heart size, in kidney function, and in other ways. Bilateral supradiaphragmatic splanchnicectomy certainly fulfills these requirements as shown by the above statistics.

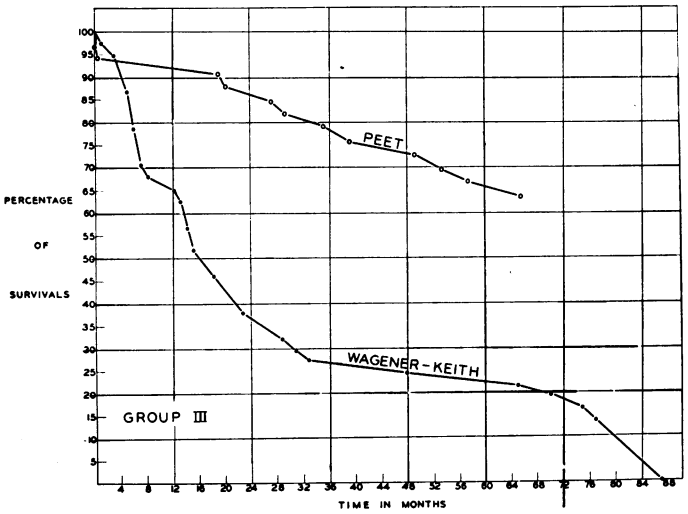
Recently we have compared our mortality after a five- to seven-year postoperative period with the Keith-Wagener table of similar patients treated medically. These cases have been grouped according to the preoperative ocular findings. Graphs 1 and 2 are from a paper by Woods and Peet which will appear in the Journal of the American Medical Association.

Group III represents a very serious type of hypertension manifested by spasm of the retinal arteries, hemorrhages, and often exudates. It will be noted in Graph 1 that the mortality in Group III when treated medically is very high. The same group when treated by splanchnicectomy has a much lower mortality.

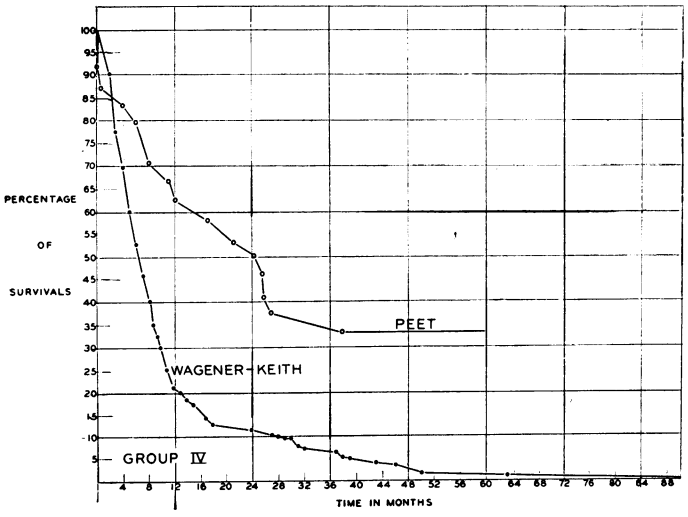
Group IV (Graph 2) represents the so-called malignant type of hypertension and is manifest by papilledema in addition to the retinal changes found in Group III

(Graph 1). The patients in this group have an exceedingly poor prognosis. It will be noted in Graph 2 that the majority of these patients died within the first year under medical treatment. The mortality in the surgical group is much higher than in any of the other groups treated surgically, but is much more favorable than the corresponding medically treated group.

I believe the data here submitted demonstrates the value of bilateral supradiaphragmatic splanchnicectomy, with resection of the lower thoracic sympathetic ganglia.



GRAPH 1.



GRAPH 2.

DR. ALFRED ADSON (Rochester, Minn.): About ten years ago, I was prompted to devise a procedure to alter the blood pressure of patients suffering from essential hypertension. The operation was based on the principle that blood pressures decrease when high spinal anesthesia is employed. The intent was to reproduce changes similar to

those that occur at the time spinal anesthesia is produced. It consisted of bilateral ventral rhizotomy which included the roots on both sides from the sixth thoracic to the second lumbar vertebrae inclusive. It was performed for the specific purpose of interruption of the vasomotor nerves in the hope that such a procedure would relieve peripheral resistance due to vasospasm. Fortunately, some satisfactory results were obtained. The magnitude of extensive laminectomy and rhizotomy stimulated me to alter the procedure in order to make it less shocking. The next procedure that I devised is bilateral subdiaphragmatic, extraperitoneal resection of the splanchnic nerves with the portion of the celiac ganglion and removal of the lumbar sympathetic trunks, including the first and second lumbar ganglia.

The results of this operation appeared to be equally as good as those that followed extensive rhizotomy. However, it soon became apparent that not all patients responded equally well to the operation. Those who obtained the best results were those whose blood pressure receded to near normal values on rest in bed and who received sodium amytal prior to operation. It also became apparent that the relief of clinical symptoms often was greater than the actual reduction of blood pressure. Patients who had beginning arteriosclerosis and those who already had sustained irreparable damage to the cardiorenal system obtained only temporary or no relief from extensive sympathectomy.

Although various approaches and procedures are employed to interrupt the vasomotor control of a large vascular region, the problem of surgical treatment still remains one of experimentation since Goldblatt, Page, and many others have shown that ischemia of the kidney with the resulting development of a vasopressor substance results in a state of hypertension that is not amenable to sympathectomy. Until such time that an antipressor substance can be produced and administered with safety, I believe we are justified in continuing extensive sympathectomy. It should not be employed indiscriminately in the light of our experiences. May we hope that the operation suggested by the essayist will be more effective than those operations that are being employed.

DR. LOYAL DAVIS (Chicago, Ill.): As Doctors Grimson and Smithwick have pointed out, the question of hypertension is a very difficult one and none of us knows all of the exact factors involved in its production. For this reason, it is important that we have a good understanding of what essential hypertension means to each of us before we can understand one another and our results. For us, the term "essential hypertension" includes those cases of chronic hypertension which neither clinically nor anatomically can be demonstrated to have evolved from an antecedent inflammatory disease of the kidneys or from urinary obstruction. In addition to a high systolic and diastolic blood pressure, the changes in the blood chemistry and the clinical stages of the disease are the important factors which must be studied.

In our own experience, the majority of patients with essential hypertension react favorably to the correct administration of potassium sulphocyanate, but there is a group of patients who are resistant to the cyanates and it is to this group that we have devoted our attention in an attempt to do something for them surgically. We have reported upon the fact that many of the patients who are resistant to the cyanates become sensitive following a bilateral supradiaphragmatic splanchnicectomy. In our second series, we are now performing a supra- and infradiaphragmatic section of the splanchnic nerves and removal of the first two lumbar sympathetic ganglia. As yet, it is too early to report upon the results in these patients but we have the impression that this combined operation is more effective.

We are interested in knowing whether or not Doctor Grimson's experimental animals showed an increase in the hematocrit reading, blood protein, and cholesterol levels in addition to their high blood pressures. This is true of the hypertension produced experimentally by ischemia of the kidneys, and, in our opinion, must be present to be correlated accurately with hypertension in man. In our own laboratory, we were able to produce hypertension in the same manner as has Doctor Grimson, but the blood chemistry studies on those animals were never analogous to the blood chemistry findings in clinical hypertension.

It is only by adding together all of the results from the various surgical procedures which are being carried out on man and the experimental investigations, that we will be able to come to some understanding about a problem which is a very difficult one.

DR. NORMAN E. FREEMAN (Philadelphia): I have been following the work of Doctors Grimson and Phemister with great interest. In our own studies, we were first interested in attempting to prevent the renal type of hypertension by sympathectomy. Four years ago, Doctor Page and I found, just as Doctors Grimson and Phemister have found, that total sympathectomy, including cardiac denervation, did not prevent the rise in blood pressure produced by constriction of the renal artery in the dog.

Three years ago, with Doctor Jeffers, I undertook some experiments on how little of the sympathetic nervous system it was necessary to remove in order to prevent the reflex nervous hypertension which took place from raising the intracranial pressure. We found, as Doctors Grimson and Phemister found, that upper thoracic or lower thoracic sympathectomy alone did not prevent it, but when we combined the two or performed total sympathectomy, the rise in blood pressure from raising the intracranial pressure could be prevented.

On analyzing our results further, we finally found it was necessary to remove only the sympathetic nerves from the heart and to exclude reflex nervous adrenal secretion in order to prevent this type of hypertension. In other words, we could leave in both sympathetic chains from the sixth thoracic to the fifth lumbar, provided we had excluded the adrenal secretion, either by taking out one adrenal and denervating the other, or taking out one adrenal and injecting novocain into the medulla of the other gland.

It would seem from the analogy of the development of malignant hypertension in patients and malignant hypertension in dogs after constriction of the renal artery, that there is a close relationship between the experimental hypertension of Goldblatt and clinical hypertension. On the other hand, I do not think that the nervous influence has been excluded. I think it may be possible that the nervous influence produces its effect by way of renal vasoconstriction. In our own clinical work, we have followed the technic of thoracolumbar sympathectomy, suggested by Smithwick, in order to provide as complete as possible a sympathectomy of the renal area.

DR. GEORGE J. HEUER (New York, N. Y.): In view of the references to the effects of various surgical methods of treatment made by other speakers, I should like to refer to the results we thus far have obtained with the operation of anterior root section. In 19 patients with essential hypertension, five or more years have elapsed since we performed this operation and we are, therefore, in the position of stating the five-year results obtained. When we consider the course of the disease, its progressive nature, its eventual outcome, its tendency to recur, if I may so speak of it, after operative treatment, we may liken it to malignant disease; and in appraising methods of treatment we should hesitate to speak of results which have not extended over a five-year period. Of the 19 patients operated upon, five or more years ago, 12 are dead. Of the 12, two lived to within a few months of five years, one lived almost four years, one lived three years, and the remaining eight from a few months to one and one-half years. Of the 12 dying, five died as a direct result of cerebral hemorrhage, seven died of cardiac disease associated with uremia. While these patients lived, four showed marked improvement in their subjective symptoms; others showed moderate improvement. With respect to their blood pressures (last observations before death), two showed the same systolic and diastolic pressure as before the operation; and ten showed a reduction in both systolic and diastolic pressure. The reduction in systolic pressure varied between 20 and 90 Mm.Hg., and averaged 50 Mm.Hg.; the reduction in diastolic pressure varied between 20 and 40 Mm.Hg., and averaged 27 Mm.Hg. When one studies the causes of death it would seem, in this group, that such reduction in blood pressure did not alter the course of the disease.

Of the seven patients in this series who are now living, all are alive six years, and six are alive from six to seven years after operation. They have all been examined recently. They appear to be in remarkably good condition. They are free from the subjective symptoms they previously had, and are all active and following their usual occupations. With respect to their blood pressures, in two, the blood pressures are normal; in three, elevated (systolic 180, diastolic 105); in two, definitely elevated (systolic 210/220, diastolic 100/120). It would appear that in some of these patients the course of the disease has been interrupted and life prolonged; but it is clear that even a longer period of observation is necessary before final results can be stated with assurance.

DR. KEITH S. GRIMSON (Chicago, closing): I am not in position to discuss the effect upon hypertension of splanchnicectomies of the various types. There have been more than 1,800 operations of this type performed and, as time goes along, an accurate postoperative study should properly evaluate the procedure. The high incidence of indifferent results reported after splanchnic area denervation, and the marked experimental difference between partial and total sympathectomy have led to the operation of total paravertebral sympathectomy in man. It is hoped that better results may be obtained by this procedure.

I believe that the discussers have brought out the differences of opinion concerning the various types of splanchnicectomy, and, of course, the medical men have still further differences of opinion. Studies of hypertensive patients are very difficult to control, and there has been considerable controversy about the effect of splanchnic area denervation. We have had little experience with this operation.

Doctor Curtis asked about gastric motility and sensation. This operation, as it has been performed, includes the celiac ganglia, in an effort to prevent regeneration. Motility studies have shown no abnormality. It is surprising how well patients can get along without the sympathetic system.

Doctor Davis asked about thiocyanate therapy. That has not been given to these patients postoperatively because as yet we have not felt that they have needed it. There is one exception. That is the patient I first spoke of, who had had a period of thiocyanate with no result; sympathectomies with very indifferent results; and then sulphocyanate—again, with still no result. There certainly is a chance that the peripheral resistance may have become so fixed in this patient that no mechanism which can be attacked is going to relax it.

I have not time to go over all of the discussion, except to say that we do fully recognize that these results are very early. We report them in the interest of an attempt to get at the mechanism of the hypertension, and in the hope that perhaps more might be accomplished by this procedure than by partial sympathectomies.