## THE EFFECTS OF PROGRESSIVE SYMPATHECTOMY ON BLOOD PRESSURE

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The close dependence of vascular tone on sympathetic impulses as shown by more or less persistent vasodilatation when the sympathetic nerves to arterioles are cut, the importance of vascular tone for the proper distribution of blood in the body, and the recent increase in the application of surgery to the sympathetic system render important an enquiry into the effect of sympathectomy on blood pressure. The work of W. B. Cannon, Lewis and Britton (1927) proved that animals can survive total abolition of sympathetic activity in the body. It was clear, therefore, that a study could be made of the effects on blood pressure of extirpating not only parts of the sympathetic system but the whole system as a distributor of tonic impulses to blood vessels.

Method. For the present study dogs between 11 kgm. and 13 kgm. in weight were used. They were found large enough to allow accurate readings of the blood pressure and small enough to make operating possible. They were trained to lie quietly on a table during the blood-pressure determinations. A typical rubber cuff, reduced in width to about 8 cm., was used, and the pressure was measured by means of a mercury manometer. The cuff was applied to the leg below the knee; a small diaphragm stethoscope, or palpation, or both, were used to determine the disappearance and reappearance of the pulse. The artery (dorsalis pedis) on the anterior surface of the foot served for the observations. By this method it was possible to get reasonably consistent results in repeated observations within a brief period under similar conditions. Care was taken to place the cuff as nearly as possible in the same position in successive readings. The heart rate was recorded with the blood pressure.

With one exception the parts of the sympathetic system were removed in the same order. The first step was the removal of both abdominal chains from the diaphragm to the sacrum and the severance of the right splanchnics at the diaphragm. The second was the removal of the right thoracic chain from the stellate ganglion to the diaphragm through which were pulled the remnants of the splanchnics. The final operation involved the removal of the left thoracic chain from the stellate ganglion to the diaphragm where the left splanchnics were cut. The animals recovered rapidly from the operations, and in each instance the readings were resumed on the following day.

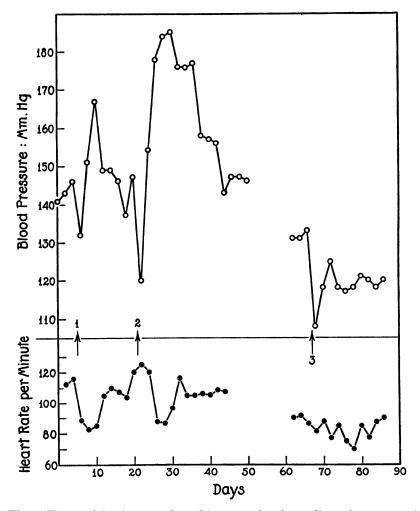


Fig. 1. The graph has been condensed by averaging the readings of two successive days (1 and 2, 3 and 4, etc.), so that there is a two-day interval between recorded readings. In each instance, however, the first record after operation is that for the next day. The numbers refer to the three steps of the sympathectomy described in the text.

RESULTS. The most complete case is recorded graphically in figure 1. The pre-operative blood pressure varied between 140 and 145 mm. Hg and the heart rate between 106 and 118 beats per minute. After extirpating

the two lumbar chains and cutting the right splanchnics the blood pressure fell to 132 mm. Hg (the next day) and gradually rose until it reached 167 mm. Hg on the sixth post-operative day. It then slowly fell to about its previous average level, near 145 mm. Hg. After removing the right thoracic chain, the blood pressure dropped to 120 mm. Hg on the first post-operative day; it then rose rapidly to 178 mm. six days later and more slowly to a maximum of 185 mm. four days after that. The rise was followed by a gradual fall to a pressure about 10 mm. lower than the previous average. The final operation, excluding from action the left thoracic chain and left splanchnics, caused a drop to 108 mm. Hg on the first post-operative day, followed by a rise to 125 mm. on the sixth day and a prompt fall to an average of about 120 mm. which continued.

The rise of blood pressure after the first and second operations (fig. 1) was associated with a reduction of the heart rate—a result in accord with Marey's law and with recent evidence of reflex bradycardia from stimulation of the nerve endings in the carotid sinus (Heymans, 1929). marked fall of pressure after the second operation was associated with a rise of the rate, but a deeper fall after the third operation was not thus associated. In both instances the vagi were intact; but in the latter instance the sympathetic supply to the heart had just been destroyed by removal of the final remnant of the sympathetic. The evidence that hypotension induces medulli-adrenal secretion (see Heymans, 1929, p. 54) shows that the sympathico-adrenal system is brought into action when the arterial pressure falls. The difference in the effects of the pressure-drop on the cardiac rate, attending a difference in the sympathetic supply to the heart, raises a question as to whether in hypotension the sympathetics are not more important than the vagal influences in causing acceleration.

The observations illustrated in figure 1 were confirmed in three other dogs in which the results were essentially similar. For example, in a white Spitz, the slow rise of pressure after abdominal sympathectomy amounted to about 15 mm. Hg; after right thoracic sympathectomy the pressure rose gradually about 25 mm. above the pre-operative level and then gradually returned; and after the final operation, with cutting of the left splanchnics, it fell about 30 mm. (to 108 mm. Hg) and rose thereafter to a permanent level at about 130 mm. Hg. In another instance, the order of the operations was right thoracic sympathectomy with right splanchnectomy, then lumbar sympathectomy with left splanchnectomy. It was significant that the blood pressure rose after the second operation to a range about 30 mm. above the pre-operative normal level, although all sympathetic control of splanchnic vessels and of adrenal secretion had been abolished.

The completely sympathectomized animals relied on shivering when they were exposed to a cool atmosphere, evidently a consequence of failure of the vasomotor function. No coincident effect on blood pressure was observed.

The interesting and rather surprising feature of the foregoing results is the rise of blood pressure to supernormal levels when a large part of the sympathetic control of blood vessels is excluded. It might be supposed that possibly the outlying neurones of the splanchnic area, when released from control by section of preganglionic fibres, became overactive and thus caused the higher pressure. But the same phenomenon appeared after removal of the right thoracic sympathetic when only the outlying neurones of the cervical distribution were isolated, and it did not occur after removal of the left thoracic chain when the splanchnic and the cervical regions were both isolated. It seems probable that the phenomenon is due to an overcompensation by the remnant of the sympathetic system, at each step except the last, for the part that has gone. How the effect is produced is not clear.

Rowntree and Adson (1929) have reported a case of Raynaud's disease of the hands in which a bilateral cervico-thoracic ganglionectomy was performed. A few years previously the patient had had a bilateral lumbar ganglionectomy for the same condition in the legs. Thus the patient was without vasomotor control in the four extremities and the head. A series of blood pressure readings was recorded after the cervico-thoracic ganglionectomy; three weeks after the operation the blood pressure, which had been 120/80 mm. Hg, had risen to 175/110; it returned gradually to the previous normal average (about 120/80) recorded four months after the operation. Their observation has a resemblance to those recorded above on dogs.

## SUMMARY

After removal of the lumbar sympathetic chains and severance of the right splanchnics, and again after removal of the right thoracic sympathetic chain from dogs, the blood pressure undergoes an initial fall which is followed promptly by a rise which gradually reaches a level considerably above normal before it slowly returns to approximately the previous normal range. After complete exclusion of sympathetic control of the blood vessels (by final extirpation of the left thoracic sympathetic chain and severance of the left splanchnics) the blood pressure drops lower than after the previous operations and then returns to about the normal level, without any noteworthy rise above that level (see fig. 1).

Extreme changes of blood pressure, before removal of the last of the sympathetic connections, were accompanied by inverse changes of the heart rate (see fig. 1).

I wish to express appreciation to Dr. W. B. Cannon for suggesting this study and for help in the operations.

## BIBLIOGRAPHY

Cannon, W. B., J. T. Lewis and S. W. Britton. 1927. Bost. Med. Surg. Journ., exevii, 514.

HEYMANS, C. 1929. Le Sinus Carotidien. Louvain and Paris. ROWNTREE, L. G. AND A. W. ADSON. 1929. Journ. Amer. Med. Assoc., xciii, 179.