THE AUTONOMIC NERVE SUPPLY OF THE DISTAL COLON

AN ANATOMICAL AND CLINICAL STUDY

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It appears certain that the effective treatment of some diseases of the distal colon, such as Hirschsprung's disease and some forms of constipation, lies in the performance of a sympathectomy. This noteworthy advance in surgery, based as it is on the foundation laid by Gaskell, Langley, and Anderson, is due to the work of many surgeons within recent years. Important contributions have been made by Wade, Trumble, Learmonth, Royle, Rankin, Adson, and others.

While there is general agreement that the treatment of such diseases of the colon as we believe to depend on autonomic imbalance must be by sympathectomy, there exists a great diversity in the methods and technique of the operation. There are wide differences in the views of surgeons as to the mode of attack, and these differences are reflected in the variety of operations which have been employed. Excision of the lumbar sympathetic cord, ramisectomy of the medially directed rami of the cord (lumbar splanchnic nerves), resection of the presacral nerve, and perivascular sympathectomy of the "aortic" plexus and of that around the inferior mesenteric artery have all been employed either singly or in various combinations. Moreover, some surgeons have reported cases in which their operation has been restricted to the left side, a method which, although success has been reported, is obviously incomplete. The distal colon must on embryological and anatomical grounds derive a symmetrical supply from the autonomic system.

Although good results have been claimed for all these operations it is much to be desired that a standard method be found; such method should be, as far as is possible, physiologically sound, easy, and safe of execution. It is unlikely that all of the above methods fulfil these postulates, and indeed some of the routes are open to the criticism that they may involve destruction of sympathetic and parasympathetic fibres alike; a result which, if our present view of autonomic function be correct, is plainly undesirable.

It is evident, therefore, that any inquiry into the best route must begin with a consideration of the course by which the sympathetic and parasympathetic fibres reach the distal colon. The ultimate distribution of each is mainly, probably entirely, by a perivascular course along the inferior mesenteric artery and its branches, but the route by which each approaches the artery is not the same. There is general agreement as to the sympathetic supply.

ANATOMICAL SECTION

It is convenient first to review the arrangement of the sympathetic fibres in the lower part of the abdomen and pelvis, since this investigation has confirmed a number of points.

Sympathetic Supply

Extending downwards from the coeliac plexus and its extensions on the antero-lateral aspects of the aorta, on each side, are usually one, two, or three fine bundles of nerve fibres, to which the name intermesenteric nerves

has been applied. These nerves are joined laterally by rami from the upper lumbar ganglia, or adjoining parts of the lumbar sympathetic cord, of their own side. Trumble¹ figures two rami on each side, but although this seems to be the commonest arrangement, the number was found to be variable, like the number of lumbar ganglia. Sometimes as many as four rami are to be observed on one side, and they do not as a rule in man converge upon the inferior mesenteric artery as shown in Trumble's figures, but join primarily the intermesenteric nerves in front of the aorta. These rami are not infrequently referred to as the lumbar splanchnic nerves, and it is evident from both dissections and surgical experience that, when three or four are present, it is the upper two on each side which are principally concerned with the innervation of the distal colon. On the right side the lumbar splanchnic nerves approach the intermesenteric nerves from behind the inferior vena cava. There are usually two or three slender strands of nerve fibres passing across the aorta to connect the intermesenteric nerves of the two sides; these strands are often to be seen both above and below the point of origin of the inferior mesenteric artery. The fibres which connect the intermesenteric nerves of the two sides do not form a plexus, and our observations support the view recently emphasized by Davis² that a true aortic plexus does not exist.

The inferior mesenteric plexus is formed by a number of sets of fibres arising from the medial sides of the right and left intermesenteric nerves, and these fibres form a dense network around the inferior mesenteric artery about half to three-quarters of an inch beyond its origin. It is clear from the dissections that the inferior mesenteric plexus receives sympathetic fibres from both sides, as is to be expected on developmental and other grounds. It is also evident that the source of these fibres is the upper lumbar ganglia, and not to any important extent from the intermesenteric nerves descending from the coeliac plexus. From the dense plexus around the stem of the inferior mesenteric artery perivascular fibres can be traced along all the branches of this vessel.

Below the origin of the inferior mesenteric plexus three descending bundles are usually to be found, which converge to form the hypogastric plexus. The two lateral trunks are direct continuations of the intermesenteric nerves after they have contributed fibres to the intermesenteric plexus. The left lateral trunk passes down behind the inferior mesenteric artery or its branches. The intermediate or middle trunk has more complicated connexions. It is commonly connected with the intermesenteric nerves of the two sides, and, in addition, communicates directly with the inferior mesenteric plexus. Careful dissection shows that some of these fibres are definitely descending *through* the inferior mesenteric plexus, but the arrangement of others suggests that they are ascending *to* the plexus. Dissection cannot definitely decide the origin of these fibres, and several possibilities must be considered.

1. They might be sympathetic fibres from the sacral or lowest lumbar ganglion ascending to the plexus.
2. It is possible for them to be parasympathetic fibres, from the sacral splanchnic nerves (*nervi erigentes*), which pass up to the colon through the hypogastric plexus.
3. Fibres from both the above sources may be represented.
4. It seems more probable that they are really descending fibres arising from the ganglion cells in the inferior mesenteric plexus, and that the arrangement suggesting that they are passing up to the plexus is misleading.

The most important question from a clinical aspect is whether these fibres are parasympathetic or not. At the outset of this investigation we thought it probable that the parasympathetic supply to the distal colon reached the

inferior mesenteric artery through the hypogastric plexus, but the fibres under discussion appeared to be insufficient for such an extensive distribution, and, furthermore, it was impossible to trace any connexion between them and the sacral splanchnic nerves. While it is impossible to exclude the hypogastric plexus as a path for a few parasympathetic fibres to the colon, it is clear from subsequent investigations that this is not the main source, and it can only supplement to some extent the chief path which is to be described. If the middle trunk of the hypogastric plexus conveys sympathetic fibres to the inferior mesenteric plexus it is also certain that this source is quite unimportant compared with the much larger supply from above through the upper lumbar splanchnic nerves of the two sides.

It is unnecessary to refer further to the hypogastric plexus, as our findings agree so closely with those recently

To show the sympathetic and parasympathetic supply to the distal colon: I.N., intermesenteric nerves; L.S.N., lumbar splanchnic nerves; I.M.P., inferior mesenteric plexus; P., parasympathetic fibres for distal colon; H.P., hypogastric plexus.

published by Elant³ and Davis.² Inferiorly the hypogastric plexus divides, and each division becomes continuous with the pelvic plexus which is joined by the pelvic splanchnic nerves (parasympathetic). We have not attempted to define the sacral roots from which the parasympathetic fibres arose in each of our dissections.

The Parasympathetic Supply

It is when we come to consider the parasympathetic innervation that we find our knowledge to be much more vague. Only by more exact information of the course of the parasympathetic fibres can we ensure their safety at operation, and it was with this object that the present inquiry was undertaken.

Many anatomical textbooks merely mention that the distal colon receives parasympathetic fibres, and none appears to give any accurate information on this subject. Quite recently Maclaren Thompson⁴ has stated with reference to the superior and inferior mesenteric plexuses: "It is not yet established whether these sympathetic plexuses in man are joined by parasympathetic fibres

from the vagi (cranial outflow), from the pelvic splanchnics (sacral outflow), from both, or from neither." In adjoining paragraphs he wisely indicates that the arrangement in different animals has been found to be "far too variable to be applied indiscriminately to man."

As just stated it has not yet been proved in man whether the parasympathetic supply for the distal colon comes from the vagi (cranial outflow) or from the pelvic splanchnic nerves (sacral outflow). Nevertheless it seems highly improbable, from our knowledge of the distribution of the vagi within the abdomen, and our own dissections, that the cranial outflow provides the parasympathetic supply to the distal colon. In the first place, the number of vagal fibres which pass from the stomach to the coeliac plexus is quite inadequate for such a possibility; and secondly, the only path by which such fibres could travel to the distal colon seems to be the intermesenteric nerves, which contribute few, if any, fibres to the inferior mesenteric plexus. A third point is the evidence submitted below, in which it is shown that a definite contribution to the distal colon comes from the pelvic splanchnic nerves. Although absolute proof of a sole supply of parasympathetic fibres from the sacral outflow is lacking, there seems to be no doubt that the main supply is from this source.

It has been noted previously that at first sight it would appear likely that the parasympathetic fibres from the sacral outflow would extend upwards through the hypogastric plexus to the inferior mesenteric plexus. The possibility of this course for a few parasympathetic fibres has been discussed, and it cannot be eliminated, but the number of fibres which could take this route seems inadequate for such an extensive distribution, and another path must be sought.

In the first case this obviously more important path was discovered accidentally, but its constant occurrence and arrangement has been verified by a number of subsequent dissections. On examining closely the lower part of the hypogastric and pelvic plexuses a small bundle of fibres can be seen on their ventral aspect on each side. The two bundles are easily separated from the main plexuses and can be traced upwards, where they converge to meet and fuse to the left side of the hypogastric plexus. The small trunk, formed by the fusion of the two bundles, can be followed upwards and to the left over the left common iliac artery to the inferior mesenteric plexus, which it joins about one to one and a half inches distal to the origin of the artery from the aorta. On joining the inferior mesenteric plexus the fibres mix with the sympathetic fibres, but with care it can be seen that these parasympathetic fibres extend as a perivascular plexus mainly on to the left colic artery and its ascending and descending divisions. Near the point where the main parasympathetic trunk crosses the left common iliac artery a leash of fibres arises from its left side, and can be traced to the sigmoid and superior haemorrhoidal branches of the inferior mesenteric artery. These fibres are evidently for the supply of the pelvic colon and rectum, and can be followed to these parts of the alimentary canal. In the case of the rectum it appears probable that these fibres provide only a supplementary parasympathetic supply, since the main source is more direct, and comes from the pelvic plexuses as described in anatomical textbooks.

The fibres travelling upwards in this way to accompany various branches of the inferior mesenteric artery to the distal colon have been described as parasympathetic, and this statement can be confidently made, since it is possible, by means of a careful dissection, to follow the fibres centrally through the pelvic plexuses and to demonstrate continuity with the pelvic splanchnic nerves. In the course of the dissections it was found best to isolate the

parasympathetic fibres at first below as they lie upon the pelvic plexuses, and from this point to trace them upwards. If the dissection is made in the reverse direction it is easy to damage the fibres or to fail to find them. Thus it seems quite clear that the main path for the parasympathetic fibres to the distal colon is independent of the presacral nerve, and consists of a small but definite trunk, which comes from the pelvic splanchnic nerves of the two sides and, after piercing the pelvic plexuses, ascends on the left side of the hypogastric plexus.

CLINICAL APPLICATION OF THESE FINDINGS

Several surgeons have attempted sympathetic denervation of the distal colon by operation on the presacral nerve, and/or a perivascular stripping of the origin of the inferior mesenteric artery carried for a distance along this vessel, which ranges, in different descriptions, from a half to one inch.

Apart from the very important fact that presacral neurectomy should not be done for this purpose in males, it is further evident that the operation might involve section of the parasympathetic supply of the distal colon. This undesirable sequel might happen if the surgeon were to carry out the excision too generously in a lateral direction or, conversely, if by any chance the parasympathetic fibres were running more medially than normal. Further, if a perivascular stripping of the inferior mesenteric artery be pushed too far along the vessel the parasympathetic supply will be destroyed.

A second method, which has been followed by other workers, is the excision of the lumbar sympathetic cords. This gives excellent results in cases of Hirschsprung's disease, and in this respect our experience has been in entire accord with the results of other and older workers. But it is at least open to question whether the beneficial results are not due entirely to the section of the lumbar splanchnic nerves, which must be divided if the excision of the sympathetic cord is carried to a proper height. It is, we think, sufficient to divide only the lumbar splanchnics; a method first suggested by Wade, who, however, at least in his earlier cases, attacked only the left side, and laid stress on the division of the white (preganglionic) ramus from the first lumbar nerve.

It is often urged, and with some justice, that sympathetomy as at present performed is unnecessarily destructive. That this is so is due to the want of more exact anatomical knowledge. The surgeon is driven to do more than is requisite and necessary in order to ensure that enough is done. With increasing knowledge and experience deliberate ramisectomy should tend to replace the cruder methods of cord ganglionectomy.

It may be possible to denervate the arm of its sympathetic supply without presenting the patient with an unwanted and disfiguring Horner's syndrome. Similarly, a simple deliberate section of the lumbar splanchnic rami will, we believe, prove sufficient to cure cases of Hirschsprung's disease without involving the unwanted by-product of a permanent vaso-dilatation of the lower extremities.

This anatomical inquiry is, we think, a definite contribution to our knowledge of the innervation of the distal colon, since it has not only displayed for the first time some exact information about the parasympathetic supply, but has thrown further light on the safest and surest route by which the sympathetic supply may be cut without endangering any fibres of the parasympathetic.

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A STUDY OF HYSTERECTOMY BASED ON THE AFTER-HISTORIES OF 112 CASES *

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This investigation was undertaken with a view to finding out how far these patients were satisfied with the result of their operation; how severe their menopausal symptoms were; whether the removal of the ovaries along with the uterus was justifiable; how far sex relationship and sexual feelings were altered; and whether obesity frequently followed. Some other findings of interest are recorded. One hundred and ninety-five consecutive cases of hysterectomy operated on in hospital by the writer during eight years received a single invitation to attend in the spring of 1933; of these 112 attended—a fairly representative number, considering change of address, weather, sickness, etc.—and were submitted to a questionnaire with their old notes in front. The analysis of the tabulated facts is as follows.

Indications for Operation

Carcinoma of cervix uteri...	...	...	...	1
Malignant disease of corpus uteri	...	...	...	2
Fibroids	...	...	...	37
Post-menopausal haemorrhage	...	...	...	2
Placental mole	...	...	...	1
Double pyosalpinx	...	...	...	1
Double retroperitoneal cysts	...	...	...	1
Endometritis, salpingo-oophoritis, and endometriosis	...	...	...	67

Nature of Operation

Vaginal hysterectomy	...	...	...	4
Subtotal hysterectomy	...	...	...	98
Panhysterectomy	...	...	...	10
Both appendages removed	...	...	...	91
Neither appendages removed	...	...	...	12
Appendages of one side removed	...	...	...	9
Appendix removed	...	...	...	85
Appendix not removed	...	...	...	12
Appendix removed previously	...	...	...	15

Age Incidence

20-25	...	...	2	40-45	...	...	31
25-30	...	...	5	45-50	...	...	14
30-35	...	...	19	50-55	...	...	11
35-40	...	...	28	55-65	...	...	2

Successful and restored to work	...	...	...	109
In indifferent health	...	...	...	3

Menopausal Phenomena

Negligible or non-existent	...	...	...	29
Slight	...	...	...	17
Moderate or mild	...	...	...	27
Severe	...	...	...	35
Post-menopausal cases	...	...	...	4

Nature of Menopausal Symptoms

Flushings and sweatings	...	...	...	83
Headache	...	...	...	30
Dizziness	...	...	...	10
Irritability	...	...	...	1
Nervousness	...	...	...	11
Mental upset	...	...	...	1
Miscellaneous	...	...	...	7

In 11 cases only one of the above symptoms was present; in 42, two only; in 20, three only; in 6, more than three; in 29 the symptoms were negligible; and 4 were beyond the menopause.

Effect on Weight

Stationary	...	...	...	25
Slight increase	...	...	...	50
Considerable increase	...	...	...	29
Loss of weight	...	...	...	8

Married or Not

Married or widow	100	Unmarried	...	12
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* Read before the North of England Gynaecological Society, February 23rd, 1934.