THE INTRINSIC BLOOD VESSELS OF THE PELVIC COLON

By J. G. BROCKIS* and D. B. MOFFAT

The Cardiff Royal Infirmary, and the Department of Anatomy, University College, Cardiff

During an investigation into the state of the blood vessels in certain pathological conditions of the colon, it became necessary to know the normal distribution of blood vessels in the wall of the bowel. On referring to the literature, it was found that while the distribution of the main branches of the mesenteric vessels has been intensively studied, that of the intrinsic vessels has been largely neglected. The principal contributions to this subject have been those of Meillère (1927), Steward & Rankin (1933), and Ross (1950*a*, *b*, 1952). There are numerous points of disagreement between these and other workers who have studied the problem, and it was, therefore, decided to carry out a preliminary investigation into the distribution of the intrinsic vessels of the normal colon, before studying the diseased specimens.

MATERIAL AND METHODS

Seventeen specimens of pelvic colon were removed from subjects of various ages at autopsy. The main vessels were cannulated and injections made into the arteries and veins at pressures of 300 and 100 mm. of mercury, respectively. A preliminary irrigation with tap water or normal saline did not improve the result, and was ultimately abandoned. The injection mass consisted of red and blue Neoprene latex 572, diluted 1:1 with tap water and with the addition of a few drops of ammonia to each 100 ml. After injection, the specimens were fixed in 10% formalin acidified with hydrochloric acid. The specimens were then cut up into pieces of a convenient size, and these were placed in concentrated hydrochloric acid for periods varying from 24 to 48 hr. It was found that by controlling the time of maceration, it was possible to remove the loose connective tissue of the submucosa completely, while the muscular coat and the mucous membrane remained relatively unaffected. The specimens were then dissected under a binocular microscope. Some specimens were cleared in glycerine, xylol or Tetralin without maceration, and others were embedded in celloidin and sectioned at thicknesses varying from 200–600 μ.

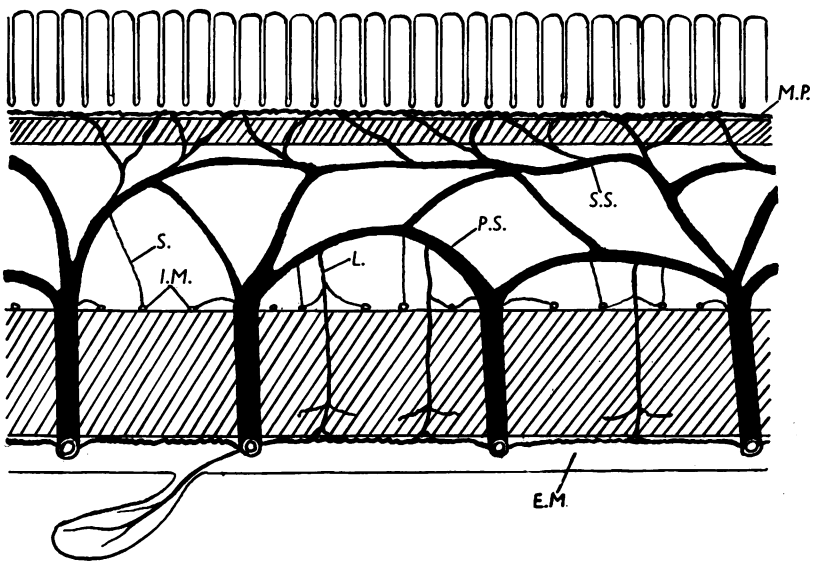
RESULTS

The main arteries which ultimately supply the colon—the arteriae rectae—run a subserous course after reaching the bowel and pierce the muscle coat at any level between the mesocolic attachment and the anti-mesocolic taeniae. Whilst in the subserosa the arteriae rectae give off a varying number of large branches which are distributed in a similar manner to the main vessels, and also numerous finer branches. The latter are distributed to the serosa, to the appendices epiploicae and to an external muscular plexus which will be described later. The arteriae rectae do not

* Present address: Dept. of Surgery, University of Western Australia, Perth, W.A.

loop into the bases of the appendices epiploicae, but remain close to the wall of the bowel so that the artery to each appendix forms a T-junction with the corresponding arteria recta (Pl. 1, fig. 1).

The course of the arteriae rectae within the wall of the bowel is shown diagrammatically in Text-fig. 1. After piercing the muscle coat, each artery gives off a number of branches in the submucosa, and continues towards the anti-mesenteric border. Some of the branches anastomose freely with branches of the neighbouring arteriae rectae to form a primary submucous plexus of large vessels. Other branches pass more deeply towards the mucosa to anastomose with other similar branches, and with branches of the primary submucous plexus to form a secondary plexus of



Text-fig. 1. Diagram to illustrate the intramural distribution of the arteriae rectae. ***E.M.***, external muscular plexus; ***I.M.***, internal muscular plexus; ***L.***, large recurrent muscular branch; ***S.***, small recurrent muscular branch; ***P.S.***, primary submucous plexus; ***S.S.***, secondary submucous plexus; ***M.P.***, mucosal plexus.

smaller vessels (Pl. 1, figs. 2, 3). At the anti-mesenteric border, there is a perfectly free anastomosis between the arteriae rectae of opposite sides of the colon (Pl. 1, figs. 3, 4). It may be misleading to give an estimate of the absolute size of the vessels in an injected preparation, but the size of the anastomosing vessels is about one-third to one-half that of the arteriae rectae where they pierce the muscle coat.

The secondary submucous plexus gives rise to numerous small arteries which pierce the muscularis mucosae to form a third or mucosal plexus on its internal aspect, and it is from this plexus that the capillaries of the mucosa are derived.

The blood supply of the muscle coats is meagre compared to the rest of the wall of the colon. The vessels form two plexuses—an internal muscular plexus, the meshes of which are arranged mainly transversely (i.e. at right angles to the long axis of the bowel), and an external plexus which is arranged longitudinally. The internal muscular plexus (Pl. 1, fig. 5), is supplied by recurrent branches from the

primary submucous plexus. These are of two types. First, the larger recurrent branches, which give branches to the internal muscular plexus and then perforate the muscle coat to join the external muscular plexus, giving off small branches which pass between the circular and longitudinal muscle layers as they do so. Secondly, the smaller recurrent branches, which break up on reaching the internal surface of the muscle coat and help to form the internal muscular plexus. The external muscular plexus (Pl. 1, fig. 6) is supplied from two sources—the larger recurrent branches from the submucous plexus, and the numerous fine lateral branches which are given off from the arteriae rectae during their subserous course.

In general, the veins accompany the arteries, but the venous plexuses in the submucosa lie nearer the mucosa. This is particularly noticeable in the case of the secondary submucous plexus, so that the branches of the secondary plexus of arteries have to straddle the corresponding plexus of veins as they pass towards the mucosa.

DISCUSSION

Besides the principal papers describing the intrinsic vessels of the large intestine which have already been mentioned, there are a number of other shorter papers describing various aspects of the problem. Most authors classify the arteriae rectae into long and short arteries, the long arteries being those which pierce the muscle coat at the level of one of the distal taeniae. Lineback (1925), for instance, depicts long arteries entering the muscle at the distal taenia and short arteries at the mesocolic taenia, with no vessels entering in the intervening interval. There seems to be little justification for such a rigid classification since, at least in the pelvic colon, the vessels may pierce the muscle coat at any level between the mesocolic attachment and the distal taeniae, and the distribution of 'long' and 'short' vessels is similar. None of the arteriae rectae are found in the subserous layer beyond the distal taeniae, so that we disagree with Meillère (1927), Fischer (1928), Petersen (1930) and Bertocchi, Zambelli & Bertocchi (1949) who found that the arteriae rectae and their terminal branches encircle the gut in the subserous layer.

The arteries which supply the appendices epiploicae are derived from the arteriae rectae. A number of authors have stated that the arteria recta, during its subserous course, passes into the base of the appendix epiploica to form a U-shaped loop which may be endangered during the excision of such an appendix at operation. This loop formation has been noted by Meillère (1927), Fischer (1928), and to a lesser extent by Pines, Rabinovitch & Biller (1941) and Bertocchi, Zambelli & Bertocchi (1949). We agree with Ross (1950*a*) that such prominent loops do not occur, and that the bases of appendices epiploicae may safely be tied as long as no traction is applied.

On the question of anastomoses between neighbouring arteriae rectae and of anastomoses across the anti-mesenteric border between arteriae rectae of opposite sides of the gut, there is considerable difference of opinion. We find that both types of anastomosis are quite free in the pelvic colon, and we therefore disagree with the majority of previous workers on the relative vascularity of the anti-mesenteric portion of the gut. Fischer (1928), Steward & Rankin (1933), Singleton (1943) and Ross (1952) all describe the anastomoses between the arteriae rectae in this region

as being 'weak' or 'scanty'. Eisberg (1924), on the other hand, believes that there is a good anastomosis in this region, and this is in accordance with our findings as can be seen in Pl. 1, figs. 3, 4. It is difficult to account for these discrepancies, but one can only assume that the 'scanty' anti-mesenteric anastomoses are due to incomplete filling of the vessels. This at any rate seems to be the case in the specimen illustrated in Fig. 14 in Steward & Rankin's paper. It would appear, from the arrangement of vessels which can be seen in our illustrations, that a transverse incision into the anti-mesenteric region of the colon would cause less bleeding than a longitudinal incision.

Very little attention has been paid previously to the blood vessels of the muscle coat; the most complete account is given by one of the early German workers (Toldt, 1870). Toldt recognized that the muscle is supplied both from without and within, and that the meshes of the plexuses are parallel to the direction of the muscle fibres. We have, however, found no previous detailed account of the blood supply of the muscle coat.

Finally, the possibility of the presence of arterio-venous anastomoses in the colon was investigated. Such structures have been mentioned by Spanner (1940) and Thamm (1940). In our double-injected specimens we have found a number of vessels in the submucosa where the red and blue injection masses meet. A few of these vessels are suggestive of true arterio-venous anastomoses, but the majority are undoubtedly distended capillaries. The demonstration of arterio-venous anastomoses by injection techniques is subject to many pitfalls, as has been pointed out by Staubesand & Hammersen (1956) and we feel that the present evidence is insufficient to enable us to give a definite opinion either way, though further investigations are in progress.

SUMMARY

1. The blood vessels of the wall of the pelvic colon have been studied by the injection of Neoprene latex 572. The arteriae rectae perforate the muscle coat at various levels between the mesocolic order and the distal taeniae, after supplying branches to an external muscular plexus, the serosa, and the appendices epiploicae. In the submucosa they form primary and secondary submucous plexuses, and from the latter, branches pierce the muscularis mucosae to form a mucosal plexus.

2. The primary submucous plexus gives recurrent branches which form an internal muscular plexus on the inner surface of the muscle coat. Some of these branches pierce the muscle, and join the external muscular plexus. The internal and external muscular plexuses are at right angles to one another.

3. There are free anastomoses between the arteriae rectae of opposite sides of the colon across the anti-mesenteric border, and between neighbouring arteriae rectae of the same side.

We should like to express our thanks to Prof. J. S. Baxter and Prof. Lambert Rogers for their help and encouragement, and to Mr Ralph Marshall of the Department of Medical Photography who took a great deal of trouble to produce the illustrations.

REFERENCES

BERTOCCHI, A., ZAMBELLI, E. & BERTOCCHI, L. (1949). Contributo allo studio dei 'vasa recta' del colon traverso. *Boll. Soc. piemont Chir.* **19**, 9–20.

EISBERG, H. B. (1924). Intestinal arteries. *Anat. Rec.* **28**, 227–242.

FISCHER, A. W. (1928). In wie weit ist durch die Ablösung des Dickdarmfeldbehanges die Sicherheit der Dickdarmnaht gefährdet. *Arch. klin. Chir.* **152**, 638–648.

LINEBACK, P. E. (1925). Studies on the musculature of the human colon, with special reference to the taeniae. *Amer. J. Anat.* **36**, 357–383.

MEILLÈRE, J. (1927). Étude de la vascularisation des tuniques du segment gauche du colon. *Ann. Anat. path. méd-chir.* **4**, 867–888.

PETERSEN, H. (1930). Beobachtung über den Feinbau verschiedener menschlicher Organe. *Z. Zellforsch.* **10**, 511–526.

PINES, B., RABINOVITCH, J. & BILLER, S. B. (1941). Primary torsion and infarction of the appendices epiploicae. *Arch. Surg., Chicago*, **42**, 775–787.

ROSS, J. A. (1950*a*). Vascular loops in the appendices epiploicae. *Brit. J. Surg.* **37**, 464–466.

ROSS, J. A. (1950*b*). The surgical significance of the intestinal vascular patterns. *Edinb. med. J.* **57**, 572–579.

ROSS, J. A. (1952). Vascular patterns of small and large intestine compared. *Brit. J. Surg.* **39**, 330–333.

SINGLETON, A. O. (1943). Symposium on surgical management of malignancy of colon. Blood supply of large bowel with reference to resection. *Surgery*, **14**, 328–341.

SPANNER, R. (1940). Die Kurzschlusswege zwischen Aorten- und Pfortadersystem sowie zwischen pfortader und Hohlvene: Arterio-venöse und portocavale Anastomosen in der Bauchhöhle des Menschen. Quoted by Clara in *Die arterio-venösen Anastomosen, Anatomie, Biologie, Pathologie*. 2nd edition. Vienna: Springer-Verlag.

STAUBESAND, J. & HAMMERSEN, F. (1956). Zur Problematik des Nachweises arterio-venöser Anastomosen im Injektionspräparat. *Z. ges. Anat.* **119**, 365–370.

STEWARD, J. A. & RANKIN, F. W. (1933). Blood supply of the large intestine. *Arch. Surg., Chicago*, **26**, 843–891.

THAMM, M. (1940). Die portocavalen Venenverbindungen des Menschen. *Zbl. Chir.* **67**, 1828–1841.

TOLDT, C. (1870). In *Manual of Human and Comparative Histology*, vol. I, S. Stricker. London: The New Sydenham Society.

EXPLANATION OF PLATE

Fig. 1. The base of an appendix epiploica, to show that the arteria recta does not loop into the appendix. (×4 approx.)

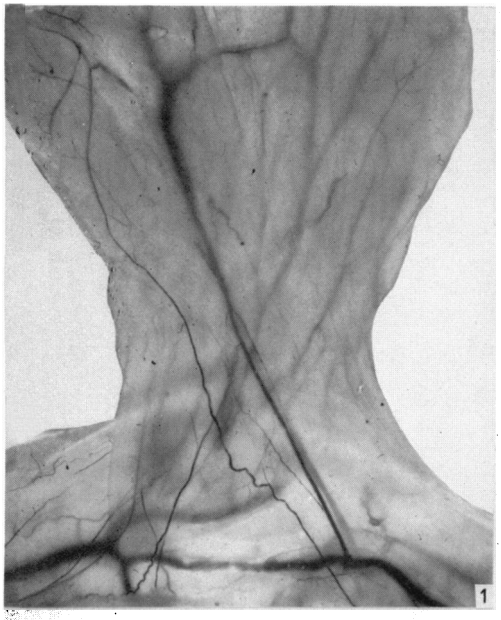
Fig. 2. The submucous plexus viewed from the outside, the muscle coat having been removed and the vessels having been divided as they pass through the muscle coat. Both arteries and veins are injected. (×5 approx.)

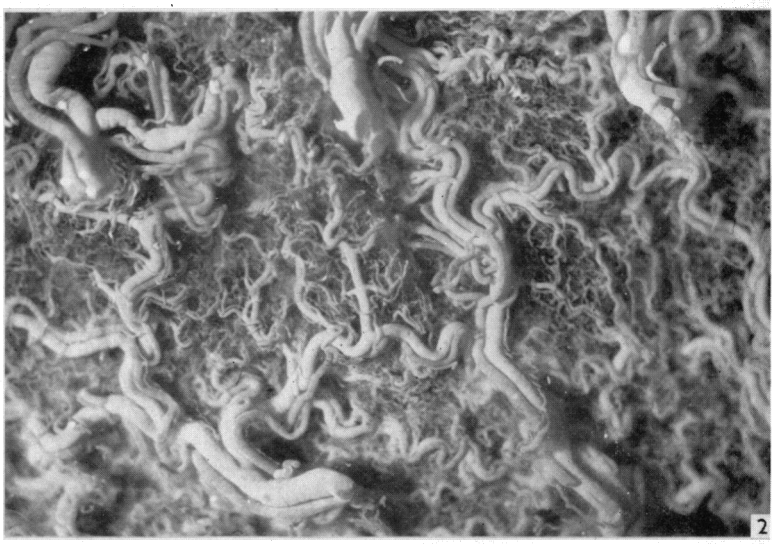
Fig. 3. A cleared specimen of mucosa and submucosa. The anti-mesenteric border lies vertically across the centre of the photograph. Both primary and secondary submucous plexuses can be seen, and in the interstices of the latter the fine vessels of the mucosal plexus are visible. (×5 approx.)

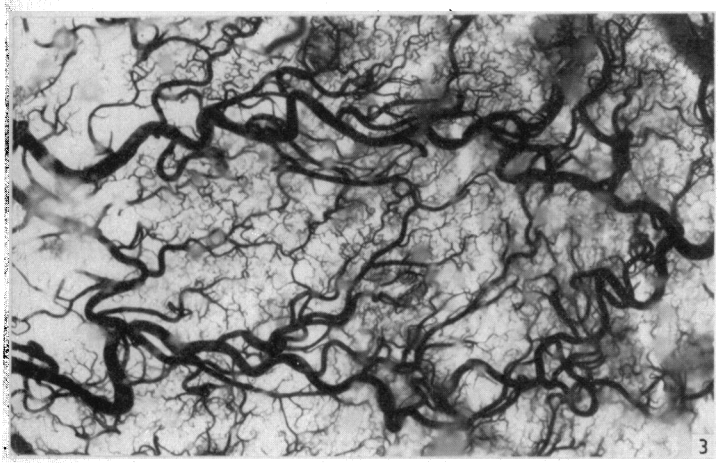
Fig. 4. A cleared specimen of the anti-mesenteric region of the colon. The anti-mesenteric border lies horizontally across the centre of the photograph, and it can be seen that there is a free anastomosis between the main vessels of the opposite sides of the bowel. (×3 approx.)

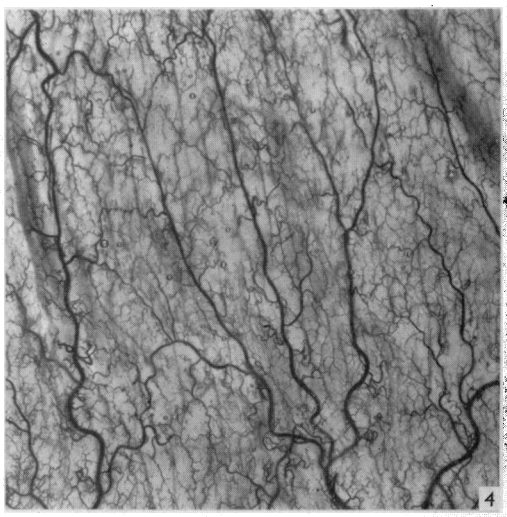
Fig. 5. The internal surface of the muscle coat to show the internal muscular plexus. The cut ends of both large and small recurrent branches can be seen. (×4 approx.)

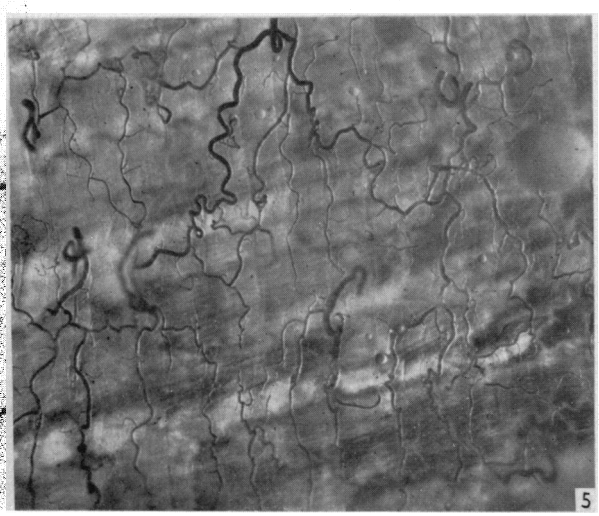
Fig. 6. The external muscular plexus. Many of the large recurrent muscular arteries can be seen piercing the muscle to join this plexus. (×6 approx.)

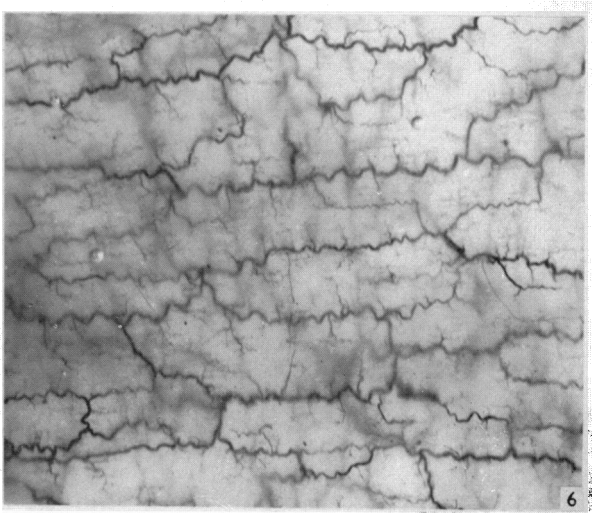












BROCKIS AND MOFFAT—INTRINSIC BLOOD VESSELS OF THE PELVIC COLON

(*Facing p.* 56)