The Functional Divisions of the Large Intestine

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THE portion of the alimentary canal in which the final processes of normal digestion occur, and in which almost all the digested food is absorbed, is the small intestine. At the lower end of this long tube is the large intestine, serving, it is usually taught, as a reservoir to receive, store, and periodically discharge the accumulation of waste. Throughout the small intestine the contents are maintained in a semi-fluid state—a state favourable to the chemical processes which the food there undergoes, and favourable also to ease its movement through the canal.

The material delivered to the colon is still semi-fluid, but in the colon the absorption of water from it causes the consistency of the waste to become more dense. This change in density of the colonic contents, however, is not uniformly spread over the total length of the colon. The soft semi-fluid or mushy mass is confined to the cæcum, ascending colon, and right third of the transverse colon.

The contents of the left two-thirds of the transverse colon, the descending and terminal colons, are, as a rule, as formed in consistency as that which is discharged through the anal canal. This difference in consistency of the colonic contents at once raises doubts in our minds as to the value of the purely anatomical subdivisions of the colon, into ascending, transverse, descending, iliac, and pelvic portions, as two distinct physiological segments are thus seen to be present : a proximal segment with soft, mushy contents, and a distal segment with contents of a firm consistency.

The desirability of giving a functional description to the large intestine was first suggested by Holzkneck (1), when he observed for the first time the movement of an opaque meal along the colon under the fluorescent screen. He stated that in this case a column of fæcal matter, corresponding to about one-third of the whole length of the colon, was suddenly displaced into the next empty compartment of similar length. This displacement, he stated further, was preceded by the disappearance of the haustral segmentation, both in the region about to be emptied, and in the next section of the gut. Immediately the latter was filled, the haustral segmentation reappeared. This procedure was repeated about three times during the twenty-four hours. Up until this observation it had been taught that the motion of the fæcal contents of the large intestine was that of a constant slow motion, causing an accumulation of the contents of the gut in the pelvic colon and rectum, with an occasional sudden evacuation.

The treatment of constipation was based on this belief, but now the term "slowing of the peristaltic motion" is no longer heard in this connection.

A. E. Barclay (2) later published similar observations on the movements of the colon. In them his observations were more accurate than those of Holzkneck, and he was able to make the following statement : At the time of the observation, the bismuth food outlined the ascending and first two inches of the transverse colon.

No shadows were detected in the rest of the transverse colon or splenic flexure. A second bismuth meal was then given, and in fifteen minutes another radiogram was taken, and this picture showed an appreciable bismuth shadow in the splenic flexure. "The picture suggests," says Barclay, "that the wave of contraction that swept the transverse colon had ceased entirely at the splenic flexure, and that the action of gravity alone had carried the food downwards through the air that happened to be present in this part of the bowel."

It is to the first part of Barclay's statement that I should like to draw special attention, i.e., that the barium shadow corresponds to the ascending colon and the proximal two inches of the transverse colon : that the shadow corresponded to the area in which the colonic contents are soft and mushy, as Barclay's "two inches" is the measurement of the shadow cast by a segment of gut photographed in a "fore-shortened" positioned. The transverse colon, as is well known, first comes forward before turning across the body to the left.

Even more accurate observations have since been made by Wingate Todd (3) by means of cinematograph pictures taken from the fluorescent screen. By this means Todd was able to demonstrate that the barium shadow fills up the ascending colon and right third of the transverse colon, and that it remains there for some time before passing onwards to the next segment of colon, which extends as far as the splenic flexure, and that the transference of the barium was not a gradual process, but taken over at one movement. As he describes it : "Without warning, the shadow spreads suddenly like a puff of smoke, into the distal colon."

The ascending, and right third of the transverse colon, which I shall now refer to as the *proximal colon,* is distinct morphologically from the remainder of the large intestine, which I shall now speak of as the *distal colon.*

These two segments have distinct nerve supplies. The proximal colon, according to Muller (4), is supplied by the upper splanchnic group of nerves, the cell stations of which are in the cœliac ganglion, while the distal colon receives splanchnic fibres from the lower splanchnic group.

In the development history of the colon, further evidence in support of this sub-division of the colon is found.

When the umbilical loop of intestine is withdrawn from the umbilical cœlom into the abdominal cavity, the colon passes obliquely from the level of the right iliac crest, below the lower pole of the right kidney, upwards and to the left to an ill-marked rounded splenic flexure, skirting on its way the greater curvature of the stomach, already, at this stage of development, of a definite shape. In this oblique part of its course, the colon crosses the second part of the duodenum and folds the latter against the dorsal abdominal wall, and where this occurs an adhesion is formed between the colon and the duodenum (5). This adhesion is an important landmark in the study of the development of the ascending colon, for the changes which take place in its formation occur around this point.

With the further growth of the colon, the gut shows two definite bulgings which quickly become well-marked curves; the segment of the gut between the duodenal

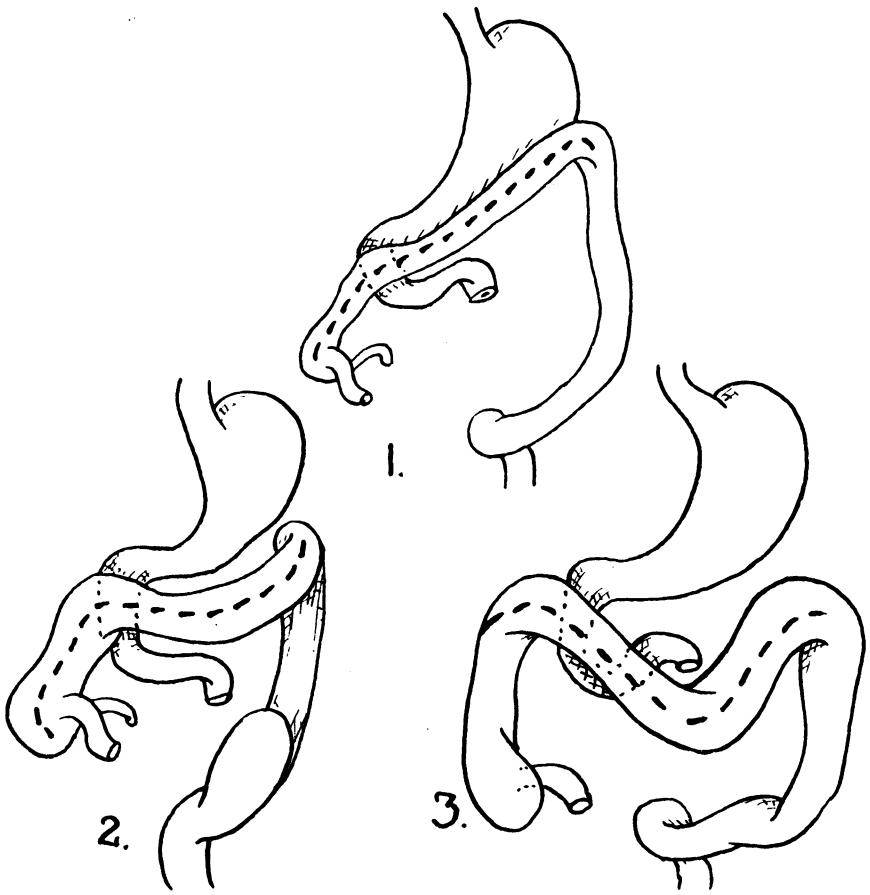
adhesion and the cæcal anlage forms a gentle curve convex to the right, and the segment between the adhesion and the splenic flexure a curve with the convexity directed caudally. By the further increase in length of the colon, these two curves become more distinct; the segment to the right of the duodenal adhesion assumes an oblique direction and marks a sharp angle at the point of adhesion with the left segment of the gut, while the latter becomes still more curved and no longer in strict apposition with the greater curve of the stomach. At this stage the right and left segments are connected to the dorsal abdominal wall by a common mesentery, but the right segment, by its continued growth, now makes a rotation on its long axis from left to right, turning over on the anterior surface of the right kidney. The mesentery of this part of the gut is thus brought against the parietal peritoneum of the dorsal abdominal wall, and the two adjacent layers being now practically immovably fixed against one another, fuse; the mesentery of this part of the colon disappears, and the bowel is left firmly fixed in the normal retro-peritoneal position of adult anatomy.

According to this description, the segment of the developing large intestine lying between the cæcal anlage and the duodenal adhesion forms the whole of the ascending colon, and that part of the transverse colon which lies between the hepatic flexure and the duodenal adhesion, i.e., the right third, the two parts being the "proximal colon," which in its development corresponds to the functional proximal colon already described.

The differentiation of the mucosa of this part adds additional reason for this account (6). It first begins near the rectum and differentiates in an oral direction, but a second point of differentiation begins at the ileo-cæcal orifice, and grows backwards, i.e., in an aboral direction. These two sets of differentiating mucosæ finally meet at a point in the gut which corresponds to the junction of the right third and left two-thirds of the transverse colon. In other words, at the junction between the proximal and distal colons.

There is, too, a difference in the character of the mucosa in the two parts. In the proximal colon it is twenty-four microns in thickness, while in the distal colon it is forty-one microns, the colon in both cases being in the contracted condition. In the distended condition the mucosa measures seventeen microns in the proximal colon and twenty microns in the distal (7).

The part of the large intestine which corresponds to the proximal colon of this description shows a further marked peculiarity—anti-peristaltic movements. These anti-peristaltic movements, or more briefly, "anastalsis," were first observed by Cannon (8) in the cat, by means of X-rays. Elliott and Barclay Smith (9) found the same movements to occur in the proximal gut of cats exposed under warm salt solution. They also observed this activity in the rat, guinea-pig, rabbit, hedgehog, and ferret. In the herbivorous animals which they studied, they found that sacculation of the proximal colon was associated with kneading movements, and that there was a direct correlation between the degree of kneading motion and the degree of sacculation.



THREE FIGURES TO ILLUSTRATE THE DEVELOPMENT OF THE COLON.

1. The Colon as it appears in a dissection of a human fœtus of 13.5 cm. C.R. length.
2. The Colon as it appears at 20 cm. C.R. length.
3. The Colon as it appears at 23 cm. C.R. length.

The existence of anastalsis in the human colon, however, has been questioned. Inferential evidence for anastalsis had been drawn from cases of cæcal fistula, but the condition had not been directly observed, until Bloch and Von Bergmann (10) by means of the X-rays, saw the contents of the cæcum and ascending colon forced at first onward to the commencement of the transverse colon, and then, after a short period, a definite retrograde movement of the contents back into the lower end of the ascending colon and cæcum. At a later date Rieder (11) brought forward further evidence, based on X-ray studies, that active anastalsis does occur in the human colon, as in that of lower forms.

The anastalsis waves seen experimentally in lower animals always begin at a tonically constricted ring on the gut wall. This tonic ring is, therefore, of prime importance in originating anastalsis, and Boehm (12) described human cases in which X-rays have revealed a narrowing of the transverse colon situated at the right of the mid-line, with undivided contents between it and the cæcum. This ring is frequently seen in the ordinary dissecting-room subjects.

The anastalsis of the proximal colon produces a thorough mixing and overturning of the material contained within it, with a consequent exposure of the semi-fluid mass to the absorbing mucosa. And as the contents of the next segment of the colon are of a more solid consistency, the first part of the colon must be regarded as a place in which digestion and absorption can occur, and thus functionally be a distinct unit, and worthy of a distinct description of its own.

It has from time to time been suggested that the cæcum and ascending colon constitute a "cess-pool," and as such, therefore, to be a source of possible injury to the economy of the animal body as a whole. Surgeons who hold this view, without hesitation freely remove this segment of the gut. Those surgeons who intelligently "follow-up" the after-results of the operation soon realised that great injury to the general health of the patient resulted, and ceased this operation. And now, when a knowledge of this functional importance of the proximal colon has succeeded the knowledge of its morphology, it can be readily understood why it cannot be removed with impunity.

The old anatomical description of ascending, transverse, descending, iliac, and pelvic colons must be relegated to the darkness of the past, and a new description worthy of the importance of part adopted—a description based on function and morphology, i.e., a proximal digestive and absorbent portion consisting of ascending and right-third of the transverse colon; and a distal segment consisting of the remainder of the large intestine, which has practically no power of absorption, and with a secretory power probably limited to the formation of mucus for lubrication of the fæces, which is stored there until a suitable opportunity for defæcation occurs.

References.

(1) E. Holzkneck, 1910, *Archives of the Roentgen Ray,* Vol. XIV, p. 273.
(2) A. E. Barclay, 1912, *Archives of the Roentgen Ray,* Vol. XVI, p. 442.
(3) Wingate Todd, 1929, *Beaumont Foundation Lectures,* Series No. 9, p. 72.
(4) Muller, 1911, *Deutches Arch. f. klin. Med., Leipzig,* Bd. 105, p. 1.
(5) R. H. Hunter, 1928, *Journ. of Anat.,* Vol. LXII, p. 298.
(6) F. P. Johnston, 1913, *Amer. Jour. of Anat.,* Vol. XIV, p. 187.
(7) R. Harvey, 1908, *Anat. Record.,* Vol. II, No. 4, p. 129.
(8) W. B. Cannon, 1902, *Am. Jour. Physiol.,* Vol. VI, p. 265.
(9) Elliott and Barclay Smith, 1904, *Jour. Physio.,* XXXI, p. 272.
(10) Bloch and von Bergmann, 1911, *Med. Klin.,* Vol. VII, p. 219.
(11) E. Rieder, 1912, *Fortschr. a. d. Geb. d. Röntgenstrablen,* Vol. XVII, p. 118.
(12) M. Boehm, 1911, *Deutsch. Arch. f. klin. Med.,* Vol. CII, p. 444.

Plate No. 1—Dr. R. H. Hunter's Paper

PLATE 1.

X-ray photograph of a barium enema showing the functional divisions of the large intestine. The opaque meal is lying in the first functional part of the colon. The second functional part is subdivided into two segments. The proximal of these segments is empty, and the distal shows the opaque meal. The first functional part is in a state of anastalsis, and the proximal third of the transverse portion thus appears empty.