THE SURGICAL ANATOMY OF THE ANAL CANAL AND RECTUM.

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EMBRYOLOGY.

In the early embryo the allantois, which lies in the body stalk, is situated at the hind end of the foetus and is at first merely a continuation of the hind gut. As growth proceeds, the hind end of the embryo assumes a curvature and the allantois and body stalk are displaced ventrally. The differentiation of the allantois and hind gut is now easy to see and the sharp bend between the two becomes dilated to form the cloaca.

During the backward growth of the embryo, its dorsal portion grows more quickly than the ventral so that there is now a portion of gut lying behind the junction of the allantois and hind gut. This is known as the post-allantoic gut. The hind gut and post-allantoic gut soon become shut off from the allantoic portion of the cloaca by the uro-rectal septum which grows down from the junction of the allantois and the hind gut; thus the uro-genital passages are separated from the alimentary tract.

On the ventral aspect of the post-allantoic gut, a thickening in the epiblast appears, which breaks down forming a depression called the proctodeum. It will be noted therefore that the proctodeal membrane invaginates the ventral aspect of the post-allantoic gut. This proctodeal membrane finally breaks down and its remnants represent in the adult, the free edges of the valves of Morgagni. Since the proctodeal membrane invaginates the post-allantoic gut on its ventral aspect, the sinuses of Morgagni must be deeper and more prominent on the posterior aspect of the anal canal. This is exactly what is found in the adult, and thus there appears to be no doubt that these valves mark the site of junction between the post-allantoic gut and the proctodeum.

The junction of the allantois with the hind gut is situated at the posterior limit of the body cavity: this point, in the fully developed individual, being the reflection of the peritoneum off the anterior wall of the rectum on to the bladder or vagina. The peritoneal reflection therefore, is the dividing line between the hind gut and the post-allantoic gut, and the sub-peritoneal portion of the rectum represents the post-allantoic gut of the embryo.

The commonest site for termination of the abnormal rectum is at the junction of the hind gut with the post-allantoic gut.

From the study of development, the rectum and anal canal are divisible into three parts:—

- (a) **The Pelvic Rectum or Hind Gut Portion.** This is the portion of the rectum situated above the peritoneal reflection between the first and third valves of Houston. It has no mesentery, no appendices epiploicæ, and the tænia begin to form a uniform muscle coat, and the superior hæmorrhoidal artery divides into branches which run on to the gut along the lines of the peritoneal reflection.

- (b) **The Perineal Rectum or Post-Allantoic Portion.** This forms the ampulla of the rectum and the constricted portion of the anal canal above the anal valves. Branches of the superior hæmorrhoidal artery approach the anterior surface at the peritoneal reflection and pierce the wall of this portion of the gut.
- (c) **The Proctodeum.** This is the portion of the anus below the anal valves.

Malformations of the Rectum.

Malformations of the rectum have been lucidly explained by Keith in terms of comparative anatomy. The cloaca in the amphibian receives both the urinary and genital ducts and the termination of the rectum. In man, the cloaca is represented by the trigone of the bladder and a portion of the urethra. Very occasionally, the rectum ends abnormally in the trigone and this represents the amphibian form. In the turtle, a stage further is reached, the rectum ending in the cloaca nearer the tail of the embryo than the uro-genital ducts.

The human rectum sometimes ends in the prostatic urethra just distal to the verumontanum. This type corresponds to the normal state of affairs in the turtle. Termination of the rectum as a fibrous cord at the base of the prostate represents a stage of arrest between the amphibian and the tortoise. In the further course of evolution, the anus migrates from its intra-cloacal position to an extra-cloacal one in the perineum. The various types of malformation represent various stages of development.

There are three main groups of malformations:—

(1) Persistence of the Original Communication with the Cloaca.

- A. In the male.** (a) The commonest opening (in this group) is in the urethra at the lower end of the verumontanum, i.e., distal to the uro-genital openings. When this occurs, the opening is too small to allow fæces to pass through and it is said that a sphincter muscle is present.
 - (b) The opening may be very rarely in the trigone of the bladder. Fig. 1. [Plate 1.]
 - (c) The opening may be at the internal meatus.
 - (d) The opening may be at the apex of the prostate.
 - (e) The opening is occasionally on the under surface of the penis at the frænum or at the scrotal raphe. The anus in this type is extra-cloacal but is drawn forwards by the developing penis.
- B. In the female.** (a) The commonest opening occurs in the vulva in the fossa navicularis. This corresponds to the commonest abnormality in the male. The writer has noticed in some cases that there appears to be a sphincter muscle round the termination of the rectum and, therefore, when operating for repair of this defect, it is wise to transplant not only the termination of the rectum but some of the tissue around it, including the vaginal wall at the orifice.

- (b) The rectum has been found opening into the vagina and it is said that such cases are associated with divided vagina because the rectum prevented the fusion of the Mullerian ducts.
- (2) **Abnormalities of the Post-Allantoic Gut.** (a) This portion of the gut may be entirely absent, the rectum ending at the peritoneal reflection, i.e. at the base of the prostate or posterior fornix of the vagina. There may be a fibrous cord joining the termination of the gut to the uro-genital organs.
- (b) The gut may end blindly at the same level but be displaced posteriorly by the vagina or prostate. In such cases there is a fibrous cord passing down to the anus. These facts must be remembered when exploring the perineum in such cases.
- (3) **Abnormalities of the Proctodeum.** (a) The commonest abnormality is the persistence of all or part of the proctodeal membrane producing on the one hand a stricture or on the other hand an imperforate anus.
- (b) The proctodeum may be absent or represented only by a small eminence. It is noteworthy that an external sphincter may be present when there is no evidence of a proctodeum. This fact definitely disproves the theory that the external sphincter is formed from the proctodeum.

The rectum ends in the uro-genital passages in 26% of cases of imperforate anus. As a rule, however, the proctodeum is absent when the rectum so ends, but the presence or absence of the proctodeum is no indication of the degree of development of the rectum. It has been said that the nearer the rectum is to the perineum, the better the development of the proctodeum, but this does not necessarily follow.

THE ANAL CANAL.

Though the anal canal commences embryologically at the level of the valves of Morgagni, for practical purposes it is more convenient to regard the anal canal as starting at the place where the rectum passes through the pelvic diaphragm. At this point, the pubo-rectalis portion of the levator ani muscles fuses with the longitudinal muscle coat of the rectum and, together with the deepest portion of the external sphincter and the internal sphincter, forms a prominent fibro-muscular ring. This ring is called the ano-rectal ring.

The anal canal exists as an antero-posterior slit surrounded by a strong muscular tube. It passes downwards and backwards from its commencement at the ano-rectal ring, forming almost a right-angle with the termination of the rectum. It is 1-in. to $1\frac{1}{4}$ -in. in length, depending upon the degree of contraction of the surrounding muscles. Contraction of the muscles, especially the subcutaneous portion of the external sphincter, increases its length.

The Musculature of the Anal Canal.

The muscles of the Anal Canal are:—

- (1) The external sphincter.
- (2) The pubo-rectalis portion of the levator ani muscles.
- (3) The longitudinal muscle of the rectum.
- (4) The internal sphincter.

- (1) **The External Sphincter.** The external sphincter of the anus is a trilaminar muscle, the three portions of which correspond in development to the three layers of the abdominal wall which, like the external sphincter, is derived from the primitive ventral muscle.

The three portions of the external sphincter are:—

- (a) The subcutaneous external sphincter.
- (b) The superficial external sphincter.
- (c) The deep external sphincter.

- (a) *The Subcutaneous External Sphincter* is an annular muscle encircling the lowest part of the anal canal. Not only can this muscle be felt as a distinct band, but it can also be seen lying under the skin at the anal orifice. It has no bony attachments, and its fibres decussate both anteriorly and posteriorly.

In front, a few fibres pass to the back of the scrotum forming a rudimentary retractor scroti. In the female, the subcutaneous external sphincter is usually well developed and anteriorly its fibres blend with the sphincter vaginæ.

This muscle lies immediately below the internal sphincter and is mainly in the same plane but lying slightly external. Its upper edge is separated from the lower edge of the internal sphincter by a distinct depression just inside the anal verge. This depression has been called the anal inter-muscular septum. This portion of the external sphincter is quite mobile underneath the skin and may be easily pushed outwards with a finger. Fig. 7. During contraction it will be seen to move inwards and its relation therefore to the lower edge of the internal sphincter may vary considerably. It may even overlap the lower edge of the internal sphincter externally.

- (b) *The Superficial External Sphincter.* This portion of the muscle is elliptical and lies immediately above and external to the preceding portion of the muscle. It is attached posteriorly to the coccyx and may be called the coccygeal portion of the external sphincter. It arises by aponeurotic and muscular fibres from the dorsal aspect of the coccyx and also from the ano-coccygeal raphe. The muscle passes forwards from its insertion in two halves on either side of the anal canal. Anteriorly, it is inserted into the central point of the perineum but some fibres pass to the skin and others outwards to the tuber ischii. The muscle is narrower anteriorly and posteriorly, being broadest at the sides of the anal canal.
- (c) *The Deep External Sphincter.* The deepest portion of the muscle lies immediately above and slightly external to the superficial portion. Like the subcutaneous external sphincter, it is annular and has no attachment to the coccyx. Its upper border is intimately attached, in the posterior half of its circumference, to the outer and inferior aspect of the puborectalis. It cannot be separated from this muscle. In the anterior portion of its circumference its upper edge lies quite free but some of its fibres decussate to gain attachment to the ischium, forming the transverse perinei muscles. These bony attachments help to steady the muscle during its action. Figs. 2, 3 and 11 [Plate 2].

FIG. 2.

Diagrammatic representation of the portions of external sphincter ani. Note:—the vertical levels of the various parts cannot be shown.

FIG. 3.

Diagram of sagittal section of anal canal, shewing relationship of external sphincter, internal sphincter, pubo-rectalis, Longitudinal muscle, hæmorrhoidal plexuses and lining of anal canal.

- (2) **The Pubo-rectalis Muscle.** This portion of the levator ani muscles has an important rôle in the control of continence. It forms a sling round the termination of the rectum and its junction with the anal canal. It arises in front from the lowest portion of the symphysis pubis and the adjacent part of the pubis and also from the deep layer of the triangular ligament. From this origin, it passes downwards and backwards on either side of the prostate (or vagina) and rectum. The fibres of either side are

continuous behind the rectum, so forming a strong muscle sling. The pubo-rectalis is quite a thick band of muscle which is closely adherent to the gut. In excision of the rectum, these stout fibres must be cut through before the rectum can be stripped off the posterior aspect of the prostate. Their close contact with the rectal wall must be remembered.

It will be noted that the pubo-rectalis is only related to the ano-rectal wall posteriorly and laterally, the anterior wall of the ano-rectal junction being unsupported by this muscle. The inferior aspect of the muscle lies in relation to the deep portion of the external sphincter, to which it is firmly adherent and from which it cannot be separated by dissection. Fig. 4.

FIG. 4.

Diagram of levator ani (sphincter muscles not shown).

At the level of the ano-rectal ring, the fibres of the muscle blend with those of the longitudinal muscle coat of the rectum and form a conjoined fibro-muscular band which has been called the longitudinal muscle of the anal canal. Figs. 3 and 11. [Plate 2].

The Nerve Supply of the superficial or coccygeal portion of the external sphincter is derived from perineal branches of the fourth sacral nerves which pass forwards into the muscle at the sides of the coccyx. The two remaining portions of the external sphincter are supplied by the inferior hæmorrhoidal nerves from the third and fourth sacral nerves. The inferior hæmorrhoidal nerve passes inwards from its origin from the internal pudic nerve, across the ischio-rectal fossa, where it soon divides into fine filaments which enter the two portions of the external sphincter. These fibres enter the muscles over a wide area, both in the antero-posterior and lateral planes, so that incisions near the anus do not, as a rule, interfere with the nerve supply of the sphincters. The pubo-rectalis portion of the levator ani muscle is supplied by the third and fourth sacral nerves from the internal pudic, representing the sphincteric portion. The remainder or tail portion of the levator ani is supplied by the fourth sacral nerve on its pelvic surface.

- (3) **The Longitudinal Muscle of the Rectum.** This fibro-muscular structure is of varying thickness but can always be easily demonstrated. It appears to be better developed on the anterior and posterior aspects of the anal

canal. It passes downwards from the level of the ano-rectal ring, enveloping the internal sphincter and lying between it and the deep and superficial portions of the external sphincter externally. Between the lower border of the internal sphincter and the upper border of the subcutaneous external sphincter, it is firmly attached to the lining of the anal canal. Its attachment is broad and somewhat fan-shaped. The lining of the anal canal is held down tightly by this insertion and the depression called the anal inter-muscular septum is produced. Most fistulæ enter the anal canal at this inter-muscular insertion of the longitudinal muscle. Some of the fibres of the longitudinal muscle pass outwards between the deep and superficial portions, between the superficial and subcutaneous portions and also between the subcutaneous portion and the skin at the anal verge, ending in the ischio-rectal fossa or peri-anal subcutaneous fat. Spread of infection from the anal canal probably occurs along these inter-muscular planes. The insertion of the longitudinal muscle holds in place non-prolapsing internal hæmorrhoids. As internal hæmorrhoids increase in size and prolapse through the anus, the longitudinal muscle is elongated but its insertion remains intact. This explains the presence of a distinct sulcus in cases of intero-external hæmorrhoids. The sulcus is much more pronounced in thrombosed prolapsed piles. In the modified Salmon operation for internal hæmorrhoids, these longitudinal fibres are divided, so exposing the sub-mucous layer. Figs. 3, 5, and 6.

FIG. 5.

Relationships and terminal attachments
of longitudinal muscles of anal canal.

[E. T. C. Milligan].

- A. Subcutaneous external sphincter.
- B. Intermuscular septum.
- C. Lower border of internal sphincter.
- D. Longitudinal muscle.
- E. Prolapsed thrombosed intero-external pile.

FIG. 6.

Relationships of longitudinal muscle
of anal canal to hæmorrhoids and
sphincters. [E. T. C. Milligan].

- A. Subcutaneous external sphincter.
- B. Submucosa with vessels.
- C. Internal sphincter.
- D. Longitudinal muscle cut and retracted.
- E. Prolapsed pile.

- (4) **The Internal Sphincter.** The internal sphincter is a continuation of the circular muscle coat of the rectum which becomes markedly thickened. It commences just above the level of the ano-rectal ring and is tubular, completely encircling almost the whole length of the anal canal. It extends downwards almost to the lower end of the anal canal and at its lower edge is just above the level of the anal inter-muscular depression. It does not end in the upper part of the anal canal as described in most textbooks of anatomy. Figs. 3, 5, 6, 7, and 11. [Plate 2].

FIG. 7.

Showing lower border of internal sphincter. Subcutaneous sphincter ani externus retracted outwards with finger.

The Nerve Supply of the internal sphincter is by means of the sympathetic and para-sympathetic systems. Its action is similar to that of the circular muscle coat of the colon and rectum. By its relaxation and contraction it helps to push fæces through the anal canal. Its action differs considerably from that of the external sphincter which, together with the pubo-rectalis, enables the act of defæcation to be controlled by the will under normal circumstances. There must exist, therefore, a very nice co-ordination between these two distinct types of muscle and it is suggested that derangements in this balance produce hypertrophy and possibly fibrous degeneration of the internal sphincter. From the study of more than forty dissections of the muscles of this region by Pallarés, we have noticed that the size of the internal sphincter varies very considerably, being especially large in the aged and in cases which have suffered from prolonged constipation.

By pushing outwards the subcutaneous external sphincter and incising the lining of the anal canal, the lower edge of the internal sphincter is seen presenting a white glistening appearance. Occasionally it can be felt tightly contracted, under an anæsthetic. The upper part of a fissure-in-ano lies over the lower end of the internal sphincter and also across the annular subcutaneous external sphincter. This latter muscle is in spasm in such cases and its division is a necessary part of the operation for cure of a chronic fissure. Fibrosis also occurs in the subcutaneous sphincter and its division produces relaxation of the anus and relief of symptoms.

From the foregoing description of the anal musculature, it is possible to palpate with precision certain landmarks.

The Ano-Rectal Ring.

This ring, as already stated, lies at the junction of the anal canal and rectum, and is composed of the pubo-rectalis sling (posteriorly and laterally only), the deep portion of the external sphincter, the longitudinal muscle of the anal canal, and the internal sphincter. It is, of course, impossible to palpate these structures separately but anteriorly the deep portion of the external sphincter can be felt as it forms the upper edge of the ano-rectal ring. The diverging fibres of the pubo-rectalis may be followed at the sides of the rectum as they pass downwards from the symphysis pubis. Figs. 8 and 9.

FIG. 8.

Palpation of posterior part of ano-rectal ring. Proximal inter-phalangeal joint at level of anus.

1. Posterior portion of ano-rectal ring.

FIG. 9.

Palpation of anterior part of ano-rectal ring. Middle of second phalanx at level of anus.

1. Anterior part of ano-rectal ring.
2. Longitudinal muscle.
3. Internal sphincter.
4. Pubo-rectalis.
5. Deep external sphincter.
6. Superficial external sphincter.
7. Subcutaneous external sphincter.

The surgical problem in the radical cure of fistulæ in ano is not the position and number of the external openings but the position of the internal opening in relation to the ano-rectal ring. If this ring is not destroyed there will not be incontinence. In front, where the ano-rectal ring is less prominent and narrower, division of the anal muscles must be done with care, since the ano-rectal ring is much more easily destroyed in this situation. The ano-rectal ring may be seen by slowly withdrawing a 2-in. proctoscope after its full introduction.

The highest part of the internal hæmorrhoidal plexus lies immediately above the level of the ring and in the high sub-mucous method of injection for hæmorrhoids, this is the correct site for injection. Fig. 3.

The Anal Inter-Muscular Septum.

The formation of this depression has already been described. It lies just inside the anal verge and if the finger be placed at the depression, the lower edge of the internal sphincter is palpated immediately above and the subcutaneous sphincter below and externally. Fig. 10.

FIG. 10.

Palpation of intermuscular septum.
Middle of distal phalanx at level of
anus.

I.S. Intermuscular Septum.

The Lining of the Anal Canal.

From the study of sections prepared by Dr. Cuthbert Dukes at St. Mark's Hospital, the following description has been obtained. Just above the level of the ano-rectal ring, where the circular muscle coat of the bowel commences to become thicker to form the internal sphincter, the columnar epithelium of the rectum becomes thinner and so also does the muscularis mucosæ. The columnar glandular epithelium continues downwards over the ano-rectal ring into the upper part of the anal canal for about half an inch or slightly less. It is dull red in colour. Below this, the columnar epithelium changes gradually to cuboid epithelium of several layers thickness. This type of epithelium extends down over the columns of Morgagni to the level of the anal valves, becoming thinner as it descends. The columns of Morgagni are formed by vessels running longitudinally in the mucosa, the mucous membrane being thrown into folds. The colour of this cuboid lining is still red but much paler than the dull red of the columnar mucous membrane.

The valves of Morgagni are situated about three-quarters of an inch below the level of the ano-rectal ring. The epithelium changes abruptly to modified squamous or a transitional type of epithelium at the level of the valves and just above this point the muscularis mucosæ disappears. This type of epithelium covers the lowest portion of the internal sphincter and is more firmly adherent to the subjacent tissues than the cuboid and columnar epithelium above. Immediately below the insertion of the longitudinal muscle of the rectum it becomes gradually more definitely squamous. Its extent is about three-eighths of an inch and its colour distinct, being pale and slightly bluish.

Below the anal inter-muscular septum, true skin is encountered and cutaneous glandular elements are present. It is at this site that Hilton's white line occurs, but this much described line is only rarely seen. The line of the valves, however, can readily be seen through a proctoscope. The subcutaneous external sphincter is covered by true skin on its anal as well as its inferior aspect. Fig. 3.

The position of the internal and external hæmorrhoidal plexuses and the connecting vessels lying in the columns of Morgagni are seen in the diagram. Internal hæmorrhoids are due to dilatation of the radicles of the superior hæmorrhoid vein lying in the internal hæmorrhoidal plexus and external hæmorrhoids are due to dilatation of the external hæmorrhoidal plexus which lies superficial to the subcutaneous external sphincter. When the connecting vessels lying in the columns of Morgagni become dilated, an intero-external hæmorrhoid is produced.

The valves and sinuses of Morgagni are more numerous and prominent on the posterior wall of the anal canal, as already stated. Lying under the epithelium in this region and also extending outwards into the substance of the internal sphincter are glandular structures described by Johnson, Dukes and others, named intra-muscular glands. These glands may open into the columns but more commonly into the sinuses of Morgagni. They are of two types, simple tubular, ending in the sub-mucosa and branched glands ending in the underlying muscles. Gordon-Watson has described several cases, in which there seems to be no doubt that a fistula-in-ano originated in these glandular structures. Tucker and Hellwig, in an investigation into the condition of cryptitis, have noted that the mucosa of the sinuses of Morgagni are not as a rule the site of infection but that the infection commences in these intra-muscular glands.

The mucous membrane above the level of the valves is either insensitive to pain or its sensation is markedly diminished. On the other hand, the epithelium at this level and below it, is highly sensitive, more so than the true skin. It is supplied by branches from the inferior hæmorrhoidal nerve. It has been pointed out by Pennington that about 85 per cent. of all proctological diseases occur in this region.

THE RECTUM.

The rectum commences opposite the third piece of the sacrum and ends at a point 1-in. in front and 1-in. below the tip of the coccyx at the level of the apex of the prostate. It is about 5-in. in length and follows the sacral curve. In addition, there are two important lateral flexures—one convex to the right opposite to the junction of the 3rd and 4th pieces of the sacrum and another to the left at the level of the sacro-coccygeal articulation. These curves must be remembered when passing a sigmoidoscope. The mucous membrane is loosely attached to the muscle coat, especially in children, so favouring prolapse. Contraction of the bowel throws the mucous membrane into folds which disappear when the rectum is distended with air. The perineal portion of the rectum is dilated to form the ampulla which, in a normal state, is empty.

There are two constant transverse folds of mucous membrane and muscle seen in the rectum, namely the valves of Houston. The proximal valve is situated on the right side at the junction of the sigmoid colon and pelvic rectum. The other, which may be called the main valve of Houston, is situated at the level of the peritoneal reflection (the junction of the hind gut and post-allantoic gut) on the anterior aspect of the bowel. Two other folds may be present, one in the pelvic rectum on the left side and the other in the perineal rectum on the left posterior aspect 1-in. above the anal canal.

When the rectum is examined with a sigmoidoscope, the opening into the sigmoid colon is usually found on the right anterior aspect of the bowel, though this is variable. Pulsation of the left internal iliac artery can usually be seen at this level.

The relations of the rectum are well known and need no repetition. The following facts, however, are important from a surgical point of view. The rectum is surrounded by its tube of visceral pelvic fascia, which becomes fused to the parietal pelvic fascia covering the sacrum. Between this composite fascia posteriorly and the rectum anteriorly there is a large quantity of fat in which lies the peri-rectal lymph sinus described by Miles, the retro-rectal lymphatic glands and the vessels and nerves. The lymphatic glands lie along the course of the main vessels which run near the wall of the gut. One inch above the levator ani muscles the parietal pelvic fascia becomes condensed to form two stout fascial supports to the rectum. These have been termed the lateral ligaments of the rectum or the rectal stalks and pass from the level of the third piece of the sacrum to the rectal wall. In them run the middle hæmorrhoidal arteries and the nervi erigentes. These structures must be divided when the rectum is being excised. The parietal pelvic fascia covering the sacrum becomes continuous with the periosteum in its lower part. When the coccyx has been excised, this dense fascia is immediately seen and it must be incised before the posterior borders of the levators can be defined and before the rectum can be separated from the front of the sacrum.

Anteriorly, lying between the rectum and the posterior surface of the prostate and seminal vessels, is a tough fascia consisting of two layers, with a potential space between them. This is attached firmly to the peritoneum above, and below to the triangular ligament in the region of the apex of the prostate. The fascia is the embryonic remains of a peritoneal pouch which extended downwards behind the prostate and has been called the prostato-peritoneal fascia of Denonvilliers. The anterior layer of this fascia is firmly attached to the posterior aspect of the prostate but its posterior layer is loosely attached to the rectal wall. The space between these two layers is opened when the rectum is dissected off the prostate. In perineal excision of the rectum, some difficulty may be experienced in finding this level at the apex of the prostate, since in this region the anterior rectal wall is held forward to the base of the triangular ligament and the apex of the prostate by two bundles of muscle derived from the longitudinal muscle coat of the rectum. This is the recto-urethralis muscle of Roux. These muscle bundles are usually quite distinct structures and if their presence is not remembered, the rectal wall is easily damaged at this point. These muscles actually angulate the rectum forwards towards the apex of the prostate. The anterior layer of the fascia of Denonvilliers above the base of the prostate is well developed, and may completely hide the seminal vesicles. It may have to be incised to verify the position of these structures.

From below, the lowest end of the peritoneal pouch is not readily found between the vesicles and the anterior rectal wall. It is more easily located by carefully cutting backwards towards the rectum. When the peritoneum has been opened, care must be taken not to continue its division too far laterally from the sulci at the sides of the rectum, since the ureters may be damaged.

The Blood Vessels of the Rectum.

The superior hæmorrhoidal artery is a continuation of the inferior mesenteric and lies behind the rectum. It divides into two branches at the level of the third piece of the sacrum and these branches pass on to the lateral aspects of the rectum following the reflection of the peritoneum.

The site and mode of division of this vessel has been studied from X-ray photographs of injected specimens and it has been found to be extremely variable, so much so that no accurate anatomical description is possible. About 4-in. above the anus, the main branches further divide and pierce the muscle coat, running down in the sub-mucous layer as straight regularly spaced vessels to end as a series of loops at the level of the internal sphincter. The superior hæmorrhoidal supplies the mucosa of the rectum and the musculature of its upper portion. It has been stated by Miles that the right main branch of the artery divides into two further branches, a right anterior and right posterior. The left main branch does not divide. These three arteries mark the position of the three primary piles. The right posterior branch and the left main branch further divide into two terminal branches indicating the site of the secondary piles. Very occasionally the left main branch again divides giving rise to an additional secondary pile anteriorly.

The middle hæmorrhoidal artery lies, as already stated, in the lateral ligaments and supplies mainly the muscle coat of the upper part of the rectum. The inferior hæmorrhoidal arteries supply the anal canal.

The Veins.

The venous return from the rectum is by means of the superior, middle and inferior hæmorrhoidal veins. The main veins follow the same course as the arteries.

The external hæmorrhoidal plexus, around the anal canal, drains mainly into the inferior hæmorrhoidal veins but also communicates with the middle and superior hæmorrhoidal veins through the internal hæmorrhoidal plexus.

The superior hæmorrhoidal vein is formed by the junction of about six vessels of considerable size which run upwards in the sub-mucosa of the rectum for three to five inches, being more or less parallel to one another and devoid of valves. They then pass through the muscle coats of the bowel and join to form, as a rule, a single venous trunk.

Since these tributaries of the superior hæmorrhoidal vein are large and run in the sub-mucosa, carcinoma cells, as they extend through the rectal wall, may easily erode a venous channel in this situation at a comparatively early stage and give rise to hepatic metastases. This may occur with quite a small carcinoma, especially when placed on the posterior wall and when it is "button-like."

It has been further noted that during the extra-rectal spread of carcinoma, growth extends along the peri-vascular lymphatics; the carcinoma spreading upwards around the walls of the vessels. Malignant cells may conceivably pass into the venous stream from the extra-rectal growth, especially in the region of the recto-sigmoid junction.

The Lymphatics.

The lymphatics of the anal canal below the level of the valves of Morgagni pass to the Inguinal Lymph Nodes.

The lymphatics of the rectum above this level are divisible into intra-mural and extra-mural. The intra-mural lymphatic vessels communicate with the lymph sinus which lies between the rectal wall and the surrounding fat. It is imperative therefore to remove with the rectum, all the fat between it and the sacrum. The extra-mural lymphatics extend in the ischio-rectal fossa to the internal iliac glands, along the upper surface of the levators to the internal iliac glands and posteriorly to the glands behind the rectum. They also extend upwards along the superior hæmorrhoidal vessels to the pelvic meso-colon and to glands at the bifurcation of the left common iliac artery. Spread of growth along all these zones is possible, but very careful dissection and histological investigation of 250 specimens of carcinoma of the rectum at St. Mark's Hospital shows that spread into the retro-rectal lymphatic glands and upwards along the main vessels, is by far the most constant. Extension into the ischio-rectal fossa or along the levators is very uncommon and only occurs in advanced inoperable growths where the main upward lymphatic channel has been blocked. In only seven cases was there evidence of downward spread and it was noted that these occurred only in very advanced cases with extensive permeation of the peri-vascular lymphatics. It is also very unusual to find involvement of the para-colic glands secondary to a carcinoma of the rectum. In this series only one case showed these glands to be involved.

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PLATE 1.

Mr. C. Naunton Morgan - Anatomy of Anal Canal and Rectum

FIG. 1. X-ray. Lateral view of pelvis, showing rectum terminating in the base of the bladder. The rectum has been filled with barium introduced through a colostomy opening and the bladder filled with 15% sodium bromide solution. The narrow channel of communication between them is shown.

PLATE 2.

Mr. C. Naunton Morgan - Anatomy of Anal Canal and Rectum

FIG. 11. Microphotograph demonstrating musculature of anal canal (Pallarés)