CHAPTER (1)

EMBRYOLOGY OF THE RECTUM AND ANAL CANAL

HINDGUT : (fig1)

The hindgut gives rise to the distal third of the transverse colon, the descending colon, the sigmoid, the rectum, and the upper part of the anal canal. The endoderm of the hindgut also forms the internal lining of the bladder and urethra.\(^7\)

The terminal portion of the hindgut enters into the posterior region of the cloaca, the primitive ano-rectal canal; the allantois enters into the anterior portion, the primitive urogenital sinus. The cloaca itself is an endoderm-lined cavity covered at its ventral boundary by surface ectoderm. This boundary between the endoderm and the ectoderm forms the cloacal membrane.

A layer of mesoderm, the uro-rectal septum, separates the region between the allantois and hindgut. This septum is derived from the merging of mesoderm covering the yolk sac and surrounding the allantois.\(^7\)

As the embryo grows and caudal folding continues, the tip of the uro-rectal septum comes to lie close to the cloacal membrane, although the two structures never make contact. At the end of the seventh week, the cloacal membrane ruptures, creating the anal opening for the hindgut and a ventral opening for the uro-genital sinus. Between the two, the tip of the uro-rectal septum forms the perineal body.

At this time, proliferation of ectoderm closes the caudal most region of the anal canal. During the ninth week, this region recanalizes.
Thus, the caudal part of the anal canal originates in the ectoderm, and it is supplied by the inferior rectal arteries, branches of the internal pudendal arteries. (8)

The cranial part of the anal canal originates in the endoderm and is supplied by the superior rectal artery, a continuation of the inferior mesenteric artery, the artery of the hindgut. The junction between the endodermal and ectodermal regions of the anal canal is delineated by the pectinate line, just below the anal columns. At this line, the epithelium changes from columnar to stratified squamous epithelium. (8)

![Diagram of Development of Anus and Rectum](image)

**Figure (1): Development of anus and rectum.** (8)

From the fifth to tenth weeks of gestation. **A,** Closing plate (proctodeum separates the cloaca from the outside). Urorectal septum (arrow) grows downward to divide the cloaca. **B,** Cloaca almost separated into dorsal rectum and ventral urogenital sinus. Tailgut is vanishing. **C,** Fusion of urorectal septum with closing plate to form the perineal body. **D,** Closing plates rupture. **E,** Division into rectum and urogenital sinus by the perineal body is complete.
ANATOMY OF COLON, RECTUM AND
ANAL CANAL

THE COLON:

The colon is conveniently considered in four parts: ascending, transverse, descending and sigmoid. The ascending colon, about 15 cm long and narrower than the caecum, ascends to the inferior surface of the right lobe of the liver, on which it makes a shallow depression; here it turns abruptly forwards and to the left, at the right colic flexure. In surface anatomy it ascends lateral to the right lateral plane from the trans tubercular to midway between the subcostal and trans pyloric planes. It is covered by peritoneum except where its posterior surface is connected by areolar tissue to the iliac fascia, and to the ilio lumbar ligament, quadratus lumborum, aponeurosis of transverses abdominis and the peri renal fascia on the front of the infero lateral area of the right kidney. The lateral femoral cutaneous nerve, usually the fourth lumbar artery, and sometimes the ilio-inguinal and ilio-hypogastric nerves, cross behind it. Anteriorly it is in contact with the coils of the ileum, the greater omentum and the abdominal wall. (7)

The transverse colon about 50 cm long, extends from the right colic flexure in the right lumbar region, across into the left hypochondrial region. Here curving sharply down and backwards below the spleen as the left colic flexure.

The transverse colon describes an arch, its concavity usually directed back and up; near its spenic end an abrupt U-shaped curve may descend lower than the main arch. Its surface projection extends from a point, situated just lateral to the right lateral plane and midway between
the subcostal and trans-pyloric planes, to the umbilicus and then up and left to a point just superior lateral to the intersection of the left lateral and trans-pyloric planes. A precise projection is difficult to deline, varying much even in the same individual. Commonly it is in the lower umbilical or upper hypogastric region. It frequently descends in a V-shaped manner, the apex being well below the level of the iliac crests.\(^9\)

The descending colon, about 25cm long, descends through the left hypochondrial and lumbar regions, at first following the lower part of the lateral border of the left kidney and then descending in the angle between the psoas major and quadratus lumborum to the iliac crest; it then curves downwards and medially in front of the iliacus and psoas major to end in the sigmoid colon at the inlet of the lesser pelvis. (It is sometimes described as ending at the iliac crest the part between this and the pelvic inlet being named the iliac colon). In surface anatomy it descends just lateral to the left lateral plane, from a little above and left of the intersection of the trans-pyloric and left lateral planes as far as the inguinal ligament. The sigmoid colon (pelvic colon) begins at the pelvic inlet, continuing in the descending part; it forms a variable loop of about 40cm and is normally in the lesser pelvis. The loop first descends in contact with the left pelvic wall, then crosses the pelvic cavity between the rectum and bladder in males and rectum and uterus in females, and may reach the right pelvic wall; finally it turns back to the midline level with the third piece of the sacrum, where it bends downwards and ends in the rectum. It is closely surrounded by peritoneum, forming a mesentery, the sigmoid meso-colon, which diminishes in length from the center towards its ends, where it disappears; the loop is fixed at its junctions with the descending colon and rectum but quite mobile between them.\(^{10}\)
Its relations are therefore variable. Laterally are: the left external iliac vessels, the obturator nerve, ovary or ductus deferens and the lateral pelvic wall, posteriorly the left internal iliac vessels, ureter, pyriformis and sacral plexus; inferiorly the bladder in males or uterus and bladder in females; superiorly and to the right it is in contact with terminal coils of the ileum. (8)

The position and shape of the sigmoid colon vary much, depending on (1) its length, (2) the length and mobility of its meso-colon, (3) the degree of distension (when distended it rises into the abdominal cavity, sinking again into the lesser pelvis when empty), (4) the condition of the rectum, bladder and uterus. (When these are distended the sigmoid colon tends to rise and to fall when they are empty). (11)

**The Rectum:**

The rectum is continuous with the sigmoid colon at the level of the third sacral vertebra, the junction being at the lower end of the sigmoid meso-colon. It descends along the sacro-coccygeal concavity, with an antero posterior curve, the sacral flexure. It thus curves down and back, then downwards, and finally down and forwards to join the anal canal by passing through the pelvic diaphragm. The ano-rectal junction is 2-3cm in front of and slightly below the coccygeal tip; from this level (in males opposite the apex of the prostate) the anal canal passes down and backwards from the lower end of the rectum, this backward bend of the gut being termed the perineal flexure of the rectum. The rectum also deviates in three lateral curves; the upper is convex to the right, the middle (the most prominent) bulges to the left and the lower is convex to the right. Both ends of the rectum are in the median plane. The rectum is about 12cm long, with the same diameter as the sigmoid colon above (about 4 cm in the empty state), but its lower part is dilated as the rectal
ampulla. The rectum differs from the sigmoid colon in having no sacculations, appendices epiploicae or mesentry; the taeniae blend about 5 cm above the recto-sigmoid junction, forming two wide muscular bands which descend, anterior and posterior, in the rectal wall.\textsuperscript{(10)}

Peritoneum is related only to the upper two-thirds, covering its front and sides above, and lower down, only its front, from which it is reflected on the bladder in males, forming the recto-vesical pouch, and on the posterior vaginal wall in females, forming the recto-uterine pouch. The level of this reflection is higher in males, the recto-vesical pouch being about 7.5 cm (about the length of the index finger) from the anus; in females the recto-uterine pouch is about 5.5 cm from the anus. In the empty rectum, the mucosa in its lower part presents a number of longitudinal folds, effaced during distension. There are also permanent semilunar transverse or horizontal folds most marked in rectal distension.\textsuperscript{(12)}

It has been suggested that the rectum consists of two functional parts, above and below the middle fold, the upper containing feces and being free to distend into the peritoneal cavity, the lower more confined, enclosed in a tube of condensed extra peritoneal tissue and (except during defecation) normally empty; in chronic constipation or after death it may contain feces. (Note that the rectum above the middle fold is considered to develop from the hindgut and the part below with the upper anal canal, from the cloaca or post-allantoic gut.\textsuperscript{(12)}

\textbf{Relations of the Rectum:} (fig 2,3)

Posterior to the rectum in the median plane are: the lower three sacral vertebrae, coccyx, median sacral vessels, ganglion impar and branches of the superior rectal vessels; while on each side, particularly on the left, are: the pyriformis, the anterior rami of the lower three sacral and
c coccygeal nerves, sympathetic trunk, lower lateral sacral vessels, the coccygei and the levatores ani. The rectum is attached to the sacrum along the lines of the anterior sacral foramina by fibro-areolar tissue enclosing: the sacral nerves and the pelvic splanchnic nerves from the anterior rami of the second to fourth sacral nerves, which join the pelvic plexuses on the rectal wall; rami of the superior rectal vessels, lymphatic vessels, lymph nodes, and loose perirectal fat.\(^{(12)}\)

Anterior in males above the site of the peritoneal reflection from the rectum, are the upper parts of the base of the bladder and of seminal vesicles the recto-vesicle pouch and its contents(Terminal coils of the ileum and sigmoid colon); below the reflection are: the lower parts of the base of the bladder and of the seminal vesicles, deferent ducts, terminal parts of the ureters and the prostate. In females, above the reflection are: the uterus, upper vagina, recto-uterine pouch and contents (terminal coils of the ileum and sigmoid colon), while below the reflection is the lower part of the vagina. Laterally, the upper part of the rectum is related to the para rectal fossa and contents (sigmoid colon or lower ileum), while below the peritoneal reflection laterally are the pelvic sympathetic plexuses, coccygei and levator ani and branches of the superior rectal vessels.\(^{(13)}\)
Figure (2): Relations of the rectum in male.  

Figure (3): Relations of the rectum in female.  

(13)
THE ANAL CANAL:

The anal canal begins where the rectal ampulla suddenly narrows, passing down and backwards to the anus. It is about 4 cm long in adults, its anterior wall being slightly shorter than its posterior. When empty its lumen is a sagittal or tri radiate longitudinal slit. Posterior is a mass of fibro muscular tissue, the ano coccygeal ligament, separating it from the tip of the coccyx; anteriorly it is separated by the perineal body from the membranous urethra and penile bulb or from the lower vagina; laterally are the ischio rectal fossae. Over its whole length it is surrounded by sphincters which normally keep it closed and Anal valves are situated along the pectinate line, opposite the middle of the sphincter ani internus and commonly considered to be the site of the anal membrane in early fetal life, thus representing the junction of the endodermal (cloacal) and ectodermal (proctodeum) parts of the canal. (14)

Small epithelial anal papillae may occur on the edges of the anal valves, perhaps remnants of the anal membrane. However, the junction of ectodermal and endodermal parts may be at the lower border of the pectin. The anal canal extends about 15 mm below the anal valves, as the transitional zone or pecten, whose epithelium is non keratinized, stratified squamous and intermediate in thickness between that of the mucosa of the upper part of the canal and the epidermis in its lowest part; only the latter contains sweat glands. (13)

Near the anal sinuses, anal glands extend upwards or downwards into the sub mucosa, occasionally penetrating deeply into the internal sphincter. Each consists of one to six spiral or straight tubules, sometimes branched, and lined by two or three layers of mucous secretory cells. The duct of each gland, lined by stratified columnar epithelium, opens into a small depression, an anal crypt. The glands are surrounded by
lymphocytes in a form similar to lymphatic follicles and the sub mucosal non striated muscles is thick in their vicinity.\(^{(14)}\)

**Anal Musculature:**

![Figure (4) : Levator plate. \(^{(15)}\)](image)

The anal walls are surrounded by a complex of sphincters, divisible into internal and external parts. At the ano rectal junction, the rectal circular muscle is thickened (5-8mm) as a non-striated sphincter ani internus around the upper three-quarters (30mm) of the anal canal and ends below at the white line. The sphincter ani externus surrounds the whole anal canal; it is usually described as consisting of three parts, all composed of skeletal muscle. These are from inferior to superior, the subcutaneous, the superficial and the deep portions. The subcutaneous part is a flat band, about 15mm broad, around the lower anal canal and lies horizontally below the lower borders of the internal sphincter and superficial part of the external sphincter; it lies beneath the skin at the anal orifice and is inferior to the white line. Anteriorly a few fibers join the perineal body (or the superficial transverse perineal muscles); posteriorly some are usually attached to the ano coccygeal ligament. The superficial part is elliptical and superior to the subcutaneous; it is the only part attached to bone, arising from the posterior surface of the terminal
coccygeal segment by the median ano coccygeal raphe; anteriorly is surrounds the lower part of the internal sphincter and is chiefly attached to the perineal body. The deep part is a thick annular band around the upper part of the internal sphincter; its deeper fibers blend in separably with the pubo rectalis; anterior to the anal canal many fibers decussate into the superficial perineal muscles, especially in females. Some posterior fibers are usually attached to the ano coccygeal raphe. However, a clear separation into three parts has also been denied (16).

The anal canal proper extends between two palpable muscular landmarks, the ano rectal ring above and the inter sphincteric ring below. In the relaxed state, the lower border of the internal sphincter and inter sphincteric groove lie at the anal orifice, the subcutaneous external sphincter being lateral to it; only when the external sphincter contracts is the orifice withdrawn around the lower part of the 'apparent' anal canal.

![Figure (5): Flap valve effect of pubo rectalis.](image)

At the ano rectal junction the pubo rectalis fig.(2) , deep external and internal sphincters collectively form the ano rectal ring of muscle, which is palpable in the canal; surgical division of this results in rectal incontinence. Its anterior part is less well marked, since relatively few
fibers of the pubo rectalis pass infront of the ano rectal junction, most forming postero lateral loops around the gut at this site, slinging the ano rectal junction forwards towards the pubis. Correlated with the dual development of the anal canal, the part above the anal valves arising from the endodermal cloaca and the part below this from the ectodermal proctodeum, the following facts emerge. (15).

The lining of the ectodermal part is skin, supplied by spinal nerves (inferior rectal), the 'somatic' inferior rectal artery, a venous drainage via the inferior rectal passing to the internal pudendal vein (systemic) and by lymphatics draining with the perianal skin to the superficial inguinal lymph nodes. In the endodermal part the mucosa is supplied by autonomic nerves , the arterial supply coming mainly from the superior rectal artery, the venous drainage by the superior rectal vein, a tributary (via the inferior mesenteric) of the portal venous system; the lymphatics drain with those of the rectum. (18)

**RECTAL FASCIAE AND SPACES: (fig 6).**

Parts of the para rectal pelvic fascia are composed of loose connective tissue, whilst others are denser , with particular orientations and attachments; the latter are often considered to be rectal 'supports' requiring surgical division to mobilize the organ. From the lower sacrum's anterior surface a strong avascular condensation proceeds to the posterior aspect of the ano rectal junction (fascia of Waldeyer). Around the middle rectal vessels fascia extends from the postero lateral pelvic wall (level with the third sacral vertebra) to the rectum as the lateral rectal ligaments. Anteriorly, between the rectum and the seminal vesicles and prostate, the recto vesical fascia is more loosely attached to the seminal vesicles and prostate than to the rectum and in rectal excision it must be separated from them (19) .
In addition to the ischio rectal fossae several 'spaces' of surgical import are related to the rectum and anal canal. The pelvi rectal space comprises the loose extra peritoneal connective tissue above the levator ani; it is divided into anterior and posterior regions by the lateral rectal ligaments. The sub mucous space of the anal canal is between the mucosa (above the white line) and the internal sphincter; it contains the superior part of the internal rectal venous plexus and lymphatic; above it continuous with the rectal sub mucosa, below with the perianal space, the lateral part of which is bounded above by the most lateral elastic septum traversing the subcutaneous part of the external sphincter. The septum divides the ischio rectal fossa into a superior part containing coarsely lobulated fat and a small, lower perianal space containing fine, compact fat. (19)

The perianal space contains the subcutaneous part of the external sphincter, the external rectal venous plexus and terminal rami of the
inferior rectal vessels and nerves. The radiating septa traversing the subcutaneous part of the external sphincter tend to divert pus in the perianal space to the anal canal at the white line or to the surface of the perianal skin, rather than to the main ischio rectal fossa. Since the perianal space surrounds the lower anal canal, pus on one side may spread around it.\(^{(20)}\)

**Vessels And Nerves Of The Large Intestine (fig 7,8):**

The arteries which supply the parts of the large intestine derived from the mid-gut (caecum, appendix, ascending colon and right two-thirds of the transverse colon) are derived from colic branches of the superior mesenteric artery; those supplying hind-gut derivatives (left part of the transverse, descending and sigmoid colon, rectum and upper anal canal) are derived from the inferior mesenteric (and its terminal branch, the superior_rectal) and the middle rectal arteries (a branch of the internal iliac). Their large branches ramify between and supply the muscular layers, divide into small sub mucosal rami and enter the mucosa. Rectal and anal canal arteries are:

1. The superior rectal (the continuation of the inferior mesenteric). This is the main rectal vessel, dividing into two rami descending one each side of the rectum, their terminal branches piercing the muscular coat to enter the rectal sub mucosa and descending into the anal columns as far as the anal valves, where they form looped nastomoses.\(^{(21)}\)
Figure (7) Blood supply of colon. (22)

Figure (8) Blood supply of rectum. (23)
2. The middle rectal arteries which traverse the 'lateral rectal ligaments' to supply the muscle of the lower rectum, anastomosing freely with each other but forming only poor anastomoses with the superior and inferior rectal arteries.

3. The inferior rectal arteries (from the internal pudendals), which supply the internal and external sphincters, the anal canal below its valves and the perianal skin. (4) The median sacral artery which supplies the posterior wall of the ano rectal junction and of the anal canal. \(^{(24)}\)

The veins of the large intestine are the superior and inferior mesenteric, draining the regions supplied by the corresponding arteries. The veins of the rectum and anal canal are: (1) The superior rectal veins, which pass from the internal rectal plexus in the anal canal and ascend in the rectal sub mucosa as about six vessels of considerable size to pierce the rectal wall about 7.5 cm above the anus, uniting to form the superior rectal vein, which continues as the inferior mesenteric. (2) The middle rectal veins, from the sub mucosa of the rectal ampulla which drain chiefly its muscular walls. (3) The inferior rectal veins, which drain the external rectal plexus and lower anal canal. Anastomoses occur between portal and systemic veins in the wall of the anal canal. \(^{(22)}\)

The never supply is sympathetic and parasympathetic (except in the lower anal canal which is somatic nerves \(^{(23)}\)). The caecum, appendix, ascending colon and right two-thirds of the transverse colon (derivative of the mid-gut) have a sympathetic supply from the celiac and superior mesenteric ganglia, and a parasympathetic supply from the vagus; the nerves are distributed in plexuses around the rami of the superior mesenteric artery \fig{9}. \(^{(23)}\)
Figure (9) : Nerve supply to rectum . \((25)\)

The left third of the transverse colon, the descending and sigmoid colon, rectum and upper anal canal (derivatives of the hind-gut) take their sympathetic supply from the lumbar part of the trunk and the superior hypogastric plexus by means of peri arterial plexuses on rami of the inferior mesenteric artery. The sympathetic supply of the colon is largely vasomotor.

The parasympathetic supply is from the pelvic splanchnic nerves (nervi erigentes), from which rami pass to the inferior hypogastric plexuses to supply the rectum and upper half of the anal canal: some fibers ascend through the superior hypogastric plexus to accompany the inferior mesenteric artery to the transverse, descending and sigmoid colon. Rami of the pelvic splanchnic nerves ascend on the posterior abdominal wall behind the peritoneum, independently of the inferior
mesenteric artery, to be distributed directly to the left colic flexure and descending colon.  

The ultimate distribution in the wall of the large intestine is as in the small intestine. Adrenergic and cholinergic activity in the nerve supply of the taenia coli, and distribution of the nerve fibers, suggest that few non-striated myocytes are directly innervated, propagation of excitation being chiefly through the gap junctions between myocytes. Sympathetic nerves to the rectum and upper anal canal pass mainly along the inferior mesenteric and superior rectal arteries and partly via the superior and inferior hypogastric plexuses, the latter supplying the lower part of the rectum and the internal anal sphincter. Parasympathetic rami from the pelvic splanchnic nerves pass forwards as long strands (about 3 cm long) from the sacral nerves to join the inferior hypogastric plexuses on the sides of the rectum, being motor to the rectal musculature and inhibitory to the internal anal sphincter.  

The external sphincter ani is supplied by the inferior rectal ramus of the pudendal nerve (S2,3) and the perineal ramus of the fourth sacral nerve. In rectal surgical excision, dissection must be kept close to its wall to avoid damage to these nerves with consequent bladder dysfunction and, in males, loss of penile erection. Afferent impulses mediating sensations of distension pass in afferent fibers in the parasympathetic nerves, pain impulses in the sympathetic and parasympathetic nerves supplying the rectum and the upper part of the anal canal. In colonic aganglionosis (mega colon) postganglionic autonomic neurons are reduced or absent in the colonic wall. In mega colon a variable diminution and sometimes absence of ganglion cells occurred, but that innervation of the muscle layers was defective even when ganglionic neurons were present.
The lymphatic drainage of the large intestine fig (10):

Lymphatic drainage of the colon: Lymphatic vessels of ascending and transverse parts of the colon end in the superior mesenteric nodes, after traversing nodes along the right and middle colic arteries and their branches. Those of the descending and sigmoid parts are interrupted by small nodes on branches of the left colic arteries, ending in the pre-aortic nodes around the origin of the inferior mesenteric artery.²⁷

Figure (10) Lymph drainage of colon.²⁷

Lymphatic drainage of the rectum and anal canal:

From the upper half, or more, of the rectum vessels emerge from its wall to ascend with the superior rectal vessels through the para rectal nodes to nodes in the lower sigmoid meso colon and along the inferior
mesenteric artery. From the lower half of the rectum and the anal canal, above its muco cutaneous junction, lymph vessels ascend through the wall to accompany the middle rectal vessels to the internal iliac nodes. Some are said to traverse the levator ani into the ischio rectal fossa, to accompany the inferior rectal and internal pudendal vessels to the internal iliac nodes. Lymphatics of the anal canal below the muco cutaneous junction descend to the anal margin, curving laterally to reach the most medial superficial inguinal nodes. (28)