The anatomy of the rectum and anal canal

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Abstract

Diseases of the rectum and anal canal, both benign and malignant, account for a very large part of colorectal surgical practice in the UK. This article emphasizes the surgically-relevant aspects of the anatomy of the rectum and anal canal.

Keywords Anal cushions; inferior hypogastric plexus; internal and external anal sphincters; lymphatic drainage of rectum and anal canal; mesorectum; perineum; rectal blood supply

The rectum[1] is the direct continuation of the sigmoid colon and commences in front of the body of the third sacral vertebra. The longitudinal orientation of the rectum conforms to the ventral concavity of the sacrum. Thus the rectum runs downwards and backwards initially, and then downwards and forwards to reach the levator hiatus (the gap in the pelvic floor between the two levator ani muscles through which the pelvic viscera pass inferiorly into the perineum).

This natural ventral bend in the rectum is termed the sacral flexure. At the levator hiatus the rectum becomes continuous with the anal canal. The ano-rectal junction is situated approximately 4 cm anterior to the tip of the coccyx. Thus the rectum, being situated above the level of the pelvic floor and below the level of the pelvic brim, is an entirely intra-pelvic viscus. In addition to displaying the ventral bend, the rectum possesses a succession of three, smooth, laterally-facing curves. The upper and lower curves are directed to the right and the middle curve to the left. (Figure 1) Each of the three 'curves' possesses, on its luminal aspect, a transverse, sickle-shaped fold. Also known as rectal shelves or the 'valves of Houston', these folds are produced by the thickened muscle in the rectal wall projecting inwards covered with overlying mucosa. The middle rectal shelf is the most constant and prominent of the three shelves and is regularly encountered during rigid sigmoidoscopy.

The inferior third of the rectum is somewhat dilated and is termed the *ampulla* (Figure 1).

The haustrations, appendices epiploicae and taeniae coli which characterize the sigmoid and other segments of the colon (see *Anatomy of the caecum, appendix and colon* in this issue) are noticeably absent on the rectal wall. Indeed it is this abrupt change in external appearance that enables the surgeon to identify the rectosigmoid junction with confidence at operation. The rectosigmoid junction usually lies approximately 6 cm below the level of the sacral promontory. Approached from the distal end, however, as when performing a rigid or flexible sigmoidoscopy, the rectosigmoid junction is seen to be 14–18 cm from the anal verge, and 18 cm is usually taken as the measurement for audit purposes.

The rectum in the adult measures 10–14 cm in length.

Relationship of the peritoneum to the rectum

Unlike the transverse colon and sigmoid colon, the rectum lacks a mesentery (Figure 1). The posterior aspect of the rectum is thus entirely free of a peritoneal covering. In this respect the rectum resembles the ascending and descending segments of the colon, and all of these segments may be therefore be spoken of as retroperitoneal. The precise relationship of the peritoneum to the rectum is as follows: the upper third of the rectum is covered by peritoneum on its anterior and lateral surfaces; the middle third of the rectum is covered by peritoneum only on its anterior surface while the lower third of the rectum is below the level of the peritoneal reflexion (the level at which the peritoneum leaves the anterior rectal wall to reach the viscus in front) and consequently has no peritoneum covering any of its surfaces. The middle rectal shelf conveniently indicates the level of peritoneal reflexion.

This relationship of the peritoneum to the rectum is readily appreciated at operation for rectal cancers when the peritoneum on either side of the rectum is incised longitudinally and the rectum is straightened during its mobilization and eventual excision.

Fascial coverings of the rectum

The entire length of the rectum (except perhaps the very distal centimetre) is surrounded by a cuff of fat termed the perirectal fat, which is generally more abundant posteriorly than anteriorly. It is in this perirectal fat that the rectal lymph nodes are located (see below under 'lymphatic drainage'), and it is in this perirectal or mesorectal fat that the superior rectal vessels travel before entering the rectum. The perirectal fat is in turn surrounded by a distinct circumferential fascial layer called the *fascia propria of the rectum*. The fascia propria enclosing the perirectal fat with the contained lymph nodes is referred to as the *mesorectum*, and it constitutes the visceral side of the '*Holy Plane*' described by Professor Heald who devised the operation of total mesorectal excision (TME).

The term does not imply that the rectum possesses a suspensory mesentery. However it is a very important principle of rectal cancer surgery that for a successful outcome, the rectum must be removed with a completely intact *mesorectum*.

Arterial supply and venous drainage of the rectum

The principal artery supplying the rectum is the superior rectal artery (Figure 1) (the name given to the inferior mesenteric artery at the point where the latter crosses the pelvic brim to enter the pelvic cavity). The superior rectal artery runs with the pelvic attachment of the sigmoid mesocolon to enter the perirectal fat behind the rectum. Here it breaks into two, sometimes three,

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[1] The word 'rectum' is derived from the latin 'rectus' meaning "straight" or "erect". The rectum was originally named in monkeys in whom the rectum is in fact straight, and not the curved structure seen in the human.

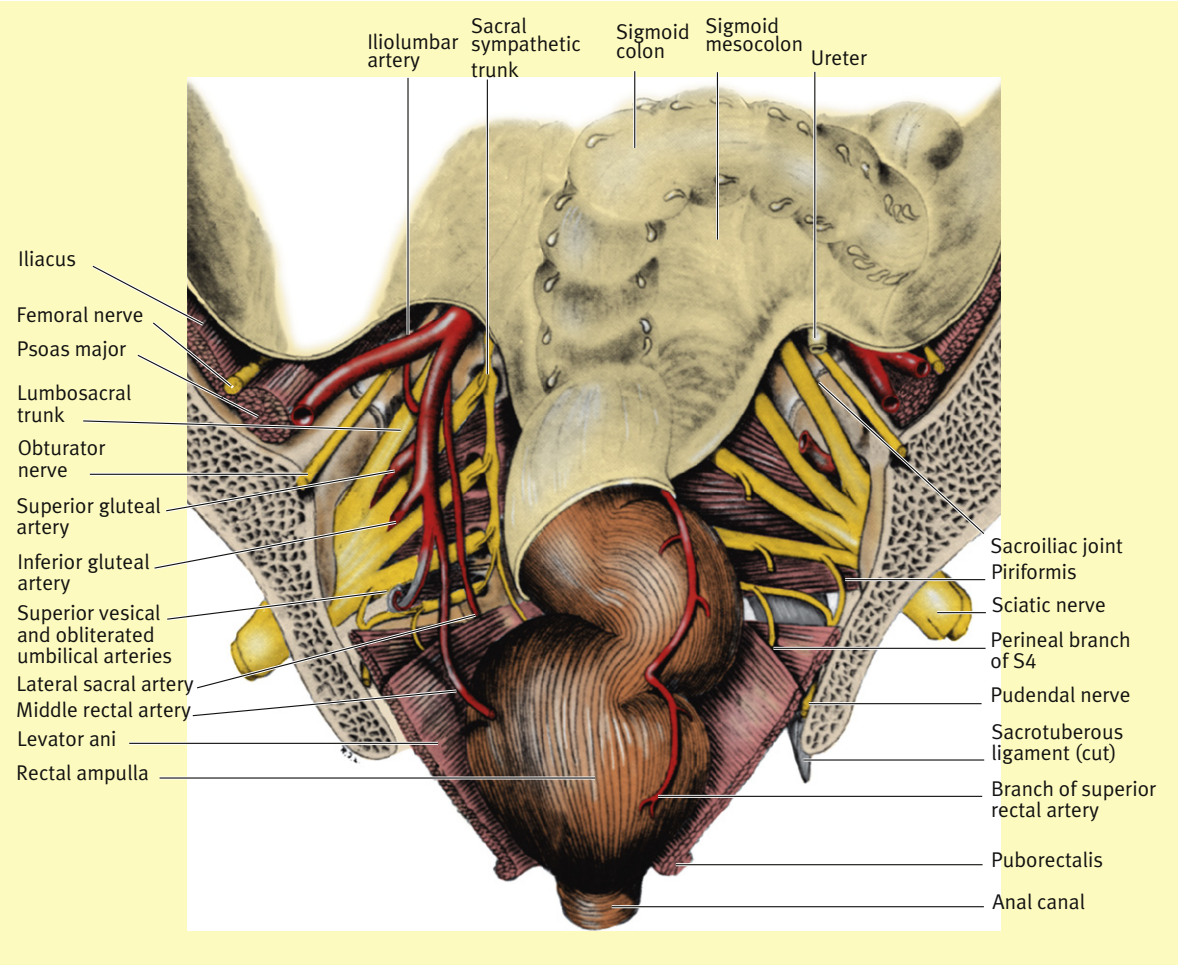

Figure 1 Coronal view of pelvic cavity showing anterior aspect of rectum.

longitudinal vessels which travel on either side of the rectum before sinking into the rectal wall.

Supplementary arteries which make a contribution to the blood supply of the rectum are the middle rectal arteries, the inferior rectal arteries and the median sacral artery. The right and left middle rectal arteries arise from the corresponding internal iliac artery and run infero-medially just above the pelvic floor to reach the rectum. The middle rectal arteries are inconstant in size both between different individuals and from side to side in the same individual. They are usually not prominent vessels but can be large enough to require separate ligation. They may be absent on one or both sides. Each inferior rectal artery is a branch of the internal pudendal artery and is given off as soon as the latter enters the perineum. The inferior rectal artery crosses the ischio-anal fossa (ischio-rectal) from lateral to medial to enter the anal wall. It is the principal artery of the anal canal. However, through the anal wall it is capable of supplying the distal third of the rectum.

The median sacral artery arises from the posterior aspect of the aorta just proximal to the aortic bifurcation. It runs down the anterior aspect of the sacrum and on reaching the pelvic floor it runs anteriorly to terminate in the rectal wall. It is usually of trivial importance where the blood supply of the rectum is concerned.

The venous drainage of the rectum mirrors the arterial supply. From a rich and valveless intramural venous plexus blood enters the valveless, perirectal venous plexus, whence rectal blood is carried mainly in the superior rectal vein. The superior rectal vein running alongside the artery, crosses the pelvic brim from below upwards to become the inferior mesenteric vein. Thereafter the inferior mesenteric vein drains the sigmoid, descending colon and splenic flexure before emptying into the splenic vein and thereby into the portal vein. Some venous blood from the intramural and perirectal venous plexuses travels bilaterally in the middle rectal veins and drains into the internal iliac veins. These veins are usually multiple and small, but can occasionally be large and require ligation. Venous blood from these rectal plexuses also finds its way through the anal wall into the inferior rectal veins which drain into the internal iliac veins via the internal pudendal veins. The anal mucosa and submucosa thus represent sites of natural porta-systemic venous anastomoses. To a limited extent these anastomoses are also present in the rectal wall. Rarely they can give rise to life-threatening rectal bleeding in portal hypertension.

Lymphatic drainage of the rectum

As with the lymphatic drainage of the rest of the colon, rectal lymph is initially received by the lymphoid follicles in the

mucosa. Thereafter, the lymph passes successively through three tiers of mesorectal lymph nodes (equivalent to epicolic, paracolic and intermediate) before reaching the so-called principal nodes. For the TNM (tumour, node, metastasis) cancer classification they are divided into those close to the rectal wall (N1) and those more centrally placed, but still within the mesorectum (N2). The principal lymph nodes that receive most of the lymph from the upper two-thirds of the rectum are the inferior mesenteric lymph nodes which are situated around the origin of the inferior mesenteric artery. Lymph from the lower third of the rectum drains into three sets of principal nodes; the inferior mesenteric lymph nodes and the internal iliac lymph nodes bilaterally (also called the pelvic side wall nodes). Adjuvant radiotherapy with curative intent as well as radical extirpative surgery must therefore address these lymph node groups.

Topographical relations of the rectum

Posteriorly, the rectum is related to (i) the ventral surface of the lower half of the sacrum and the adjoining coccyx, and (ii) the presacral space containing the median sacral vessels and the presacral venous plexus. Posterolateral to the rectum on either side lie the corresponding lumbo-sacral nerve plexus and digitations of the piriformis muscle (Figure 1). The muscle and plexus are covered anteriorly by a dense layer of pelvic fascia. Posteroinferior to the rectum is the ano-coccygeal raphe (the midline anteroposterior interdigitation of the two levator ani muscles which extends from the tip of the coccyx to the posterior aspect of the recto-anal junction). Above the raphe is a strong sheet of fascia termed the recto-sacral fascia. This layer needs specifically to be divided at surgery. Lateral to the rectum on either side lies a condensation of pelvic fascia called the lateral ligament which extends from the lateral wall of the pelvis to the rectum. In resection of the rectum this structure must be divided in order to allow full mobilization of the rectum while avoiding the leash of autonomic nerves (see below). The middle rectal arteries may or may not run within the lateral ligament before reaching the rectum. A very important lateral relation of the rectum on either side is the ipsilateral inferior hypogastric plexus, a mixed autonomic nerve plexus, carrying both sympathetic and parasympathetic fibres. The inferior hypogastric plexus is an elongated, neural mesh situated outside the rectal fascia propria, which provides all the parasympathetic and most of the sympathetic innervation to the pelvic and perineal viscera. Much of the distressing morbidity associated with radical surgery for cancers of the rectum, prostate and cervix uteri is due to inadvertent disruption of these important plexuses, and manifests as bladder dysfunction in both sexes and as erectile and/or ejaculatory dysfunction in males.

The anterior topographical relations of the rectum differ in the two sexes. In the male the rectum below the peritoneal reflexion is related to the posterior surface of the urinary bladder, the posterior aspects of the right and left seminal vesicles, the inferior parts of the two ureters, the right and left vas deferens crossing in front of the corresponding ureter behind the bladder wall, and below the bladder neck the posterior surface of the prostate where there are numerous small vessels. All of the above-named urogenital structures are separated from the fascia propria of the rectum by a distinct and fairly strong fascial layer known synonymously as rectovesical fascia, rectovesical septum and fascia of Denonvilliers. These fascial layers are clearly visible on magnetic resonance imaging (MRI) scans and are important in assessing cancer spread. Above the peritoneal reflexion, lying in front of the upper two-thirds of the rectum is a space which contains loops of small bowel and possibly the free, lower end of the greater omentum.

In the female, the rectum below the level of the peritoneal reflexion is related to the posterior wall of the intra-pelvic vagina. Above the peritoneal reflexion, the rectum is related to a gutter of peritoneal cavity called the rectouterine pouch or pouch of Douglas, which is interposed between the rectum and the posterior vaginal fornix. Above the vaginal fornix the rectum is related to the posterior surface of the body of the anteverted uterus. Between the anterior aspect of the rectum and the posterior wall of the uterus frequently there lie loops of small bowel; usually ileum.

The anal canal (Figure 2a and b) is the very terminal segment of the alimentary tract, and lies entirely below the level of the pelvic floor in the region termed the perineum. The perineum denotes the lowest part of the trunk and is situated inferior to the pelvic floor and between the proximal ends of thighs. The boundary of the perineum is best appreciated when the subject is in the lithotomy position. The perimeter of the perineum is then seen to be a diamond-shaped outline which is limited anteriorly by the inferior margin of the pubic symphysis, laterally by the right and left ischial tuberosities, and posteriorly by the coccyx. In the anatomical position, the upper limit of the perineum (roof of the perineum) is the inferior surface of the pelvic floor.

A transverse line running between the anterior ends of the right and left ischial tuberosities subdivides the perineum into two triangular areas; the urogenital triangle in front and the anal triangle behind. The anal triangle of the perineum contains the anal canal in the middle flanked by the right and left ischio-anal (ischio-rectal) fossae.

The anal canal in the adult is about 4–5 cm in length; its anterior wall being somewhat shorter than the posterior wall. From its commencement in the levator hiatus as the direct continuation of the rectum, the anal canal passes downwards and backwards. The consequent bend at the ano-rectal junction (acute angle directed posteriorly) is termed the perineal flexure, and is produced by the forward pull of the sling-like puborectalis muscle, which is of course derived from both levator ani muscles. Thus the sigmoidoscope lying in the anal canal points directly at the umbilicus, but once past this flexure it points back at the sacral hollow.

Internal appearance of anal canal (Figure 2a and b)

The mucous membrane of the anal canal as seen on proctoscopy shows a circumferential wavy mucosal fold about half-way up the anal canal. This important landmark is referred to as the *dentate line* or *pectinate line*. The upper half of the anal canal (i.e. above the dentate line) presents a variable number of vertical mucosal ridges (8–10) termed anal columns or the columns of Morgagni. Running between the lower ends of adjacent columns are a series of curved folds of mucosa called anal valves. It is these anal valves circumferentially-arranged that

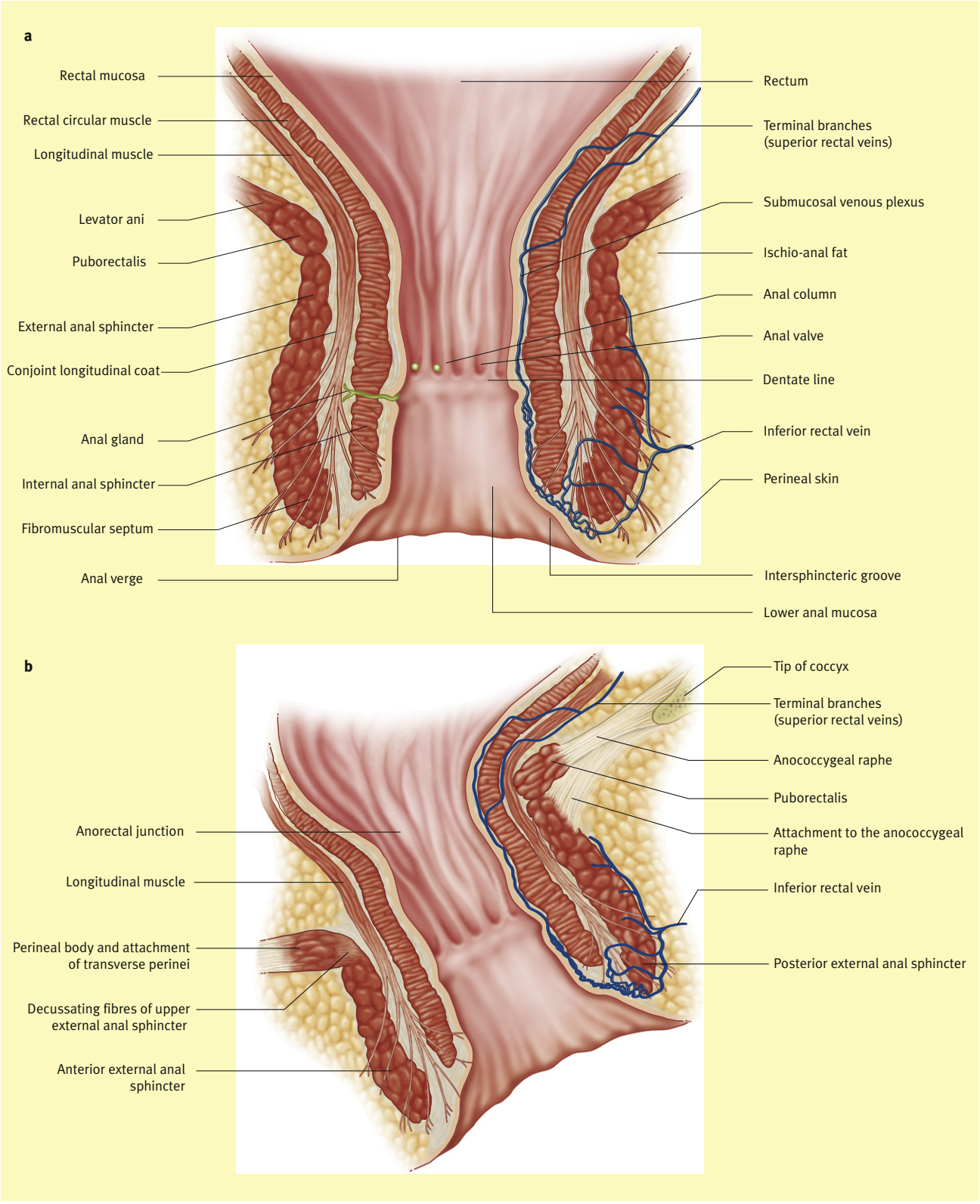

Figure 2 a Coronal view of anal canal and distal rectum; **b** Sagittal view of anal canal and distal rectum.

account for the dentate/pectinate line. Above each anal valve is a shallow mucosal pocket termed the anal sinus. Opening into each anal sinus are the ductules of a number of mucus-secreting anal glands. These glands are situated in the anal mucosa, submucosa and even as deeply as in the internal sphincter of the anal canal. A good deal of perianal sepsis is thought to be the result of infection originating in these glands.

The epithelium above the dentate line is similar to the glandular epithelial lining of the rectal mucosa and is made up of columnar cells, crypts and goblet cells. It is relatively insensitive

to pain. The anal canal distal to the pectinate line is, by sharp contrast, lined with non-keratinized, stratified squamous epithelium, and presents a smooth appearance and is very pain sensitive. Distally still, at the anal verge and just proximal to it, the anal canal is lined with sensitive, thick, hair-bearing skin.

Arterial supply and venous drainage of the anal canal

The arterial supply of the external and internal anal sphincters as well as the mucosa over the lower half of the anal canal is derived from the right and left inferior rectal arteries. The mucosa proximal to the dentate line is, however, supplied by terminal twigs of the superior rectal artery. The middle rectal arteries usually make an insignificant contribution. Within the wall of the anal canal there is a rich anastomosis between the terminations of the inferior rectal and superior rectal arteries and, for what it is worth, the terminal twigs of the middle rectal arteries.

The veins draining the anal canal correspond to the main arteries that supply the anal canal, and originate in the venous plexus situated in the anal wall. In effect, this plexus is in series with, and continuous with the intramural rectal venous plexus. Venous channels from the upper part of the anal canal (proximal to the dentate line) drain mainly into the superior rectal vein and thereby eventually to the portal venous system. Distal to the dentate line, venous drainage is mainly to the internal iliac veins either directly via the middle rectal veins or indirectly via the inferior rectal veins and internal pudendal veins. As has already been stated above, the upper half of the anal canal represents a site of natural porta-systemic anastomosis.

In addition to the intramural venous plexuses in the anal wall, and very possibly related to them, are arteriovenous mucosal cushions situated in the upper half of the anal canal. These cushions are thought to aid the internal and external anal sphincters in effecting tight closure of the anal canal. Additionally, the cushions make a modest contribution to the resting anal tone.

The lymphatic drainage of the anal canal

The dentate line marks a watershed between two different lymph node destinations for lymph from the anal canal. The distal half of the anal canal (i.e. below the dentate line) has a lymphatic drainage to the superficial inguinal lymph nodes bilaterally. Thus squamous carcinoma of the anus usually drains to the inguinal nodes and not the abdominal ones. Proximal to the dentate line, however, the anal canal drains its lymph primarily to the internal iliac lymph nodes bilaterally, and to a limited extent, to the pre-aortic, inferior mesenteric lymph nodes on the posterior abdominal wall.

Anal continence is dependent on four structures: the internal anal sphincter, the external anal sphincter, the puborectalis sling (the latter being derived from the levator ani muscles of the two sides), and the arteriovenous mucosal cushions (already mentioned above). Most of these structures are visible on an MRI scan (Figure 3), and on an ultrasound scan (Figure 4).

The internal anal sphincter is approximately 3–4 cm long and is the distal extension of the inner circular muscle layer in the rectal wall. It is nevertheless a specialized entity and may be up to 5 or 6 mm in thickness. Being made up of smooth (involuntary muscle) its motor innervation is derived from the autonomic nervous system (predominantly sympathetic). The distal edge of the internal sphincter is well-demarcated and in the normal individual, is usually easily felt.

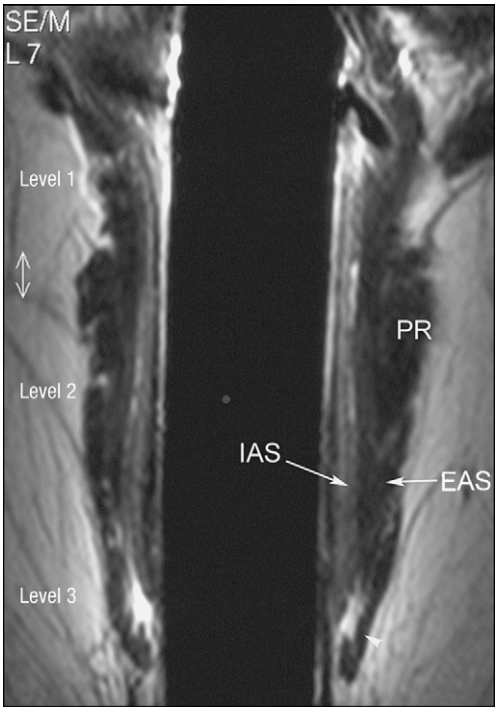

Figure 3 Coronal magnetic resonance imaging view of anal canal. (IAS, internal anal sphincter; EAS, external anal sphincter; PR, puborectalis. Levels 1, 2 and 3 denote respectively, anorectal junction, mid-anal canal and distal anal canal).

The internal anal sphincter contributes 60–75% of the resting anal tone, while the external anal sphincter and puborectalis collectively contribute about 20%. The remainder is provided by

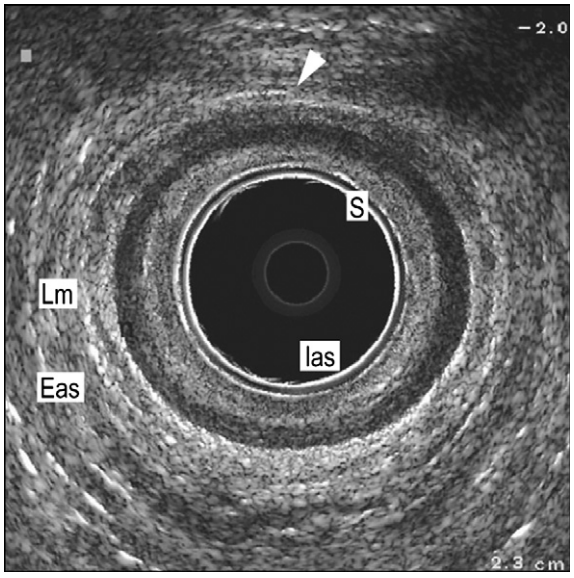

Figure 4 Ultrasound view of mid-anal canal (using an endoanal ultrasonic probe). (EAS, external anal sphincter; IAS, internal anal sphincter; Lm, longitudinal muscle; S, subepithelial tissue; white arrowhead indicates interior aspect of Eas).

the dilated anal mucosal cushions which have already been referred to above.

The external anal sphincter is conventionally described as consisting of three parts: a subcutaneous part, a superficial part and a deep part. However neither during surgical procedures on the anal canal nor in meticulously performed cadaver dissections is it possible to demonstrate three discrete parts. What is clearly seen however is that the external sphincter is longer and wider than the internal sphincter, and that the distal edge of the external anal sphincter is normally distal to that of the internal sphincter by at least 1 cm. Between these two edges, it is relatively simple to palpate the intersphincteric groove.

The external anal sphincter is made up of striated (voluntary) muscle. Its innervation is, as expected, by somatic nerves; the right and left inferior rectal nerves, each derived directly from the corresponding pudendal nerve (the nerve of the perineum).

The puborectalis sling comprises those fibres of each levator ani muscle which arise from the periosteum on the posterior surface of the pubic bone a centimetre, or more, lateral to the pubic symphysis. These fibres run posteriorly and swing medially behind the recto-anal junction to meet their counterparts from the other side. Together these fibres form a sling behind the recto-anal junction. The constant tonic contraction in this sling accounts for the sharp recto-anal angle. Voluntary relaxation of the puborectalis sling allows straightening of the recto-anal tube; a prerequisite to defaecation.

The puborectalis muscle is innervated like the rest of levator ani by the ipsilateral perineal branch of S4; a branch of the lumbo-sacral plexus.

The deepest part of the external anal sphincter blends with the puborectalis sling behind the recto-anal junction. This area of fusion is palpable on per rectal digital examination, and in surgical terminology is referred to as the ano-rectal ring. ◆