1
Anatomy of the Perineum and the Anal Sphincter

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1.1 Introduction

The anatomy of the pelvic floor, rectum and anal canal is a complex and surprisingly dynamic field with new insights, discoveries and controversies. The controversies arise as new and different tools are used to study anatomy for varying purposes. Anatomists, sprung through cadaveric dissections, propose a structure that may differ from a surgeon's depiction or understanding of the structure/function relationships of the pelvis as seen in the operating room. This controversy is best seen in describing the external anal sphincter (EAS) and the puborectalis muscle. Is the puborectalis a part of the EAS? Is the EAS a one, two, or three loop striated muscle? Perhaps all descriptions are correct, depending on the point of view and purpose of evaluation. The goal of this chapter is not to solve these controversies, but to describe the functional and structural anatomy as it is known from cadaveric dissections, radiological imaging and surgical repairs in order to improve the management of our patients.

1.2 Embryology

In the early embryo, the allantois and the hindgut open into a common cavity, the cloaca (Figure 1.1a). This is an endoderm-lined cavity that is in contact with the surface of the ectoderm. An ectodermal depression develops under the root of the tail of the fetus and sinks in towards the gut until only the thin cloacal membrane remains between the gut and the outside.[1] This ectodermal depression is called the proctodeum. The cloacal membrane is thus comprised of the cloacal endoderm and the ectoderm of the proctodeum or the anal pit. Partitioning of the cloacal membrane takes place during the fifth to seventh week of development when the urorectal septum, which is mesodermal in origin, grows down between the hindgut and the allantois to fuse with the cloacal membrane (Figure 1.1b). The area of fusion becomes the perineal body and separates the dorsal anal membrane from the larger ventral urogenital membrane. The anal membrane breaks down by the eighth week of gestation, establishing the anal canal. The urorectal septum also divides the cloacal musculature into anterior and posterior parts. The posterior portion develops into the EAS, while the anterior part becomes the superficial transverse perinei, the bulbospongiosus, the ischiocavernosus and the perineal membrane. This explains why one nerve, the pudendal nerve, supplies all musculature into which the cloacal membrane divides.[2]

Knowledge of embryology is also important to understand the differences in the linings, innervation, vascular supply and lymphatic drainage of the anal canal. The parts derived from the endoderm are lined by columnar epithelium, are innervated by autonomic nerves, and the lymphatics and veins drain towards the abdomen. The parts derived from the ectoderm are lined by stratified squamous epithelium, have a somatic nerve supply, and the veins drain towards the external iliac system, and the lymphatics to the inguinal lymph nodes.

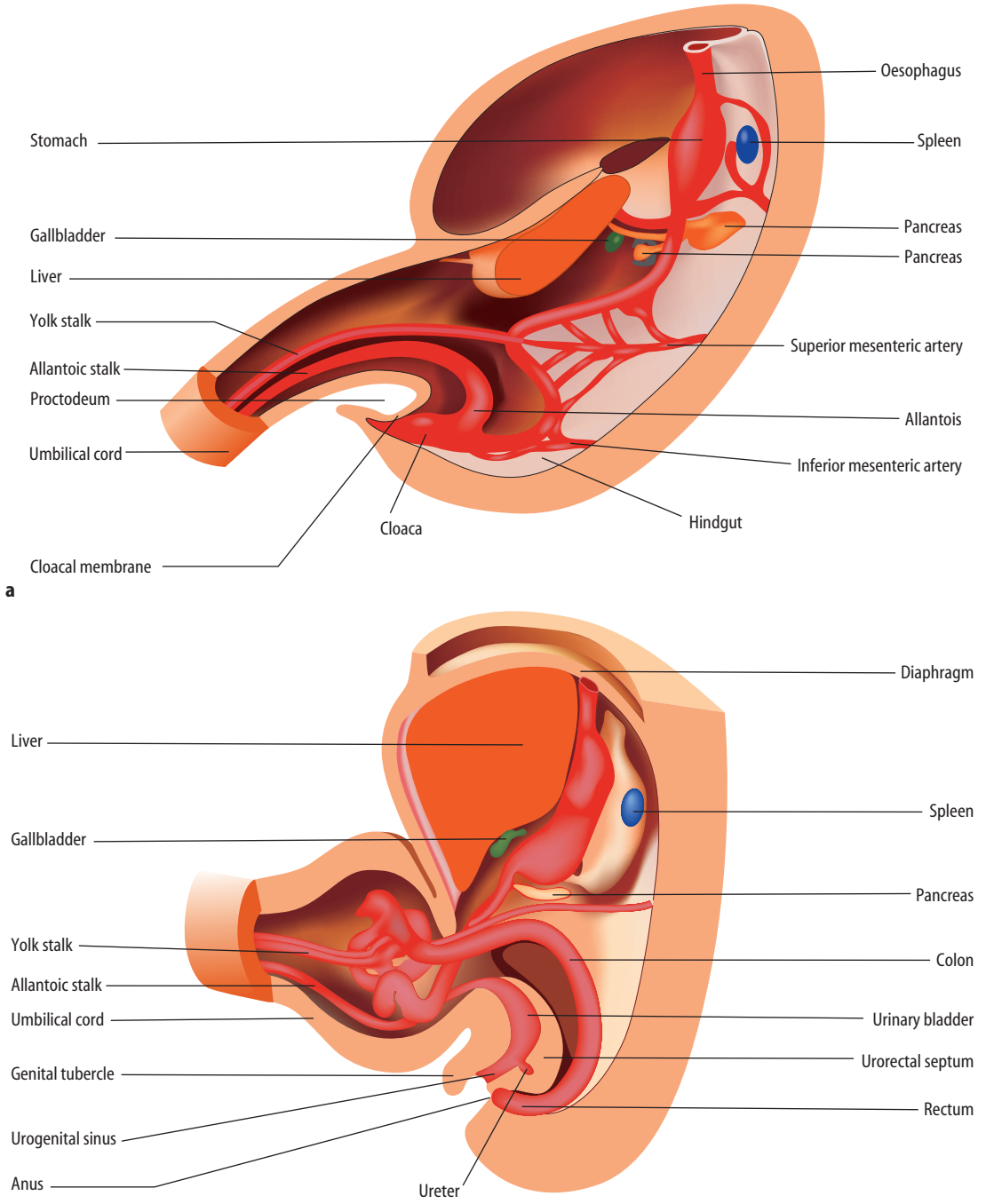

Figure 1.1. **a** Development of the gastrointestinal tract at about 5 weeks. **b** Fetus showing development of the anorectum after 5 weeks, demonstrating the growth of the urorectum towards the cloacal membrane.

The upper two-thirds (25 mm) of the anal canal is derived from the cloaca and the lower third (13 mm) develops from the proctodeum. This junction, about 2 cm from the anal verge, creates a demarcating line called the pectinate or dentate line. At this line the epithelium changes from stratified squamous to columnar cells.

Little is known about the development of the EAS and levator ani muscles. Although closely associated, embryo studies suggest the external sphincter and levator ani arise from two distinct primordia. The puborectalis muscle is a portion of the levator ani, and shares primordial with the ilio- and pubococcygeous muscles. The EAS is found after 8 weeks of gestation and is clearly distinct from the puborectalis at that time.[3]

1.3 Muscles of the Perineum

The perineum corresponds to the outlet of the pelvis and is somewhat lozenge shaped. Anteriorly, it is bound by the pubic arch, posteriorly by the coccyx, and laterally by the ischiopubic rami, ischial tuberosities, and sacrotuberous ligaments. The deep limit of the perineum is the inferior surface of the pelvic diaphragm and its superficial limit is the skin, which is continuous with that over the medial aspect of the thigh and the lower abdomen. The perineum can be divided into two triangular parts by drawing an arbitrary line transversely between the ischial tuberosities.[4] The anterior triangle, which contains the external urogenital organs, is known as the *urogenital triangle* and the posterior triangle, which contains the termination of the anal canal, is known as the *anal triangle*.

1.3.1 The Urogenital Triangle

The urogenital triangle (Figure 1.2a) is bound anteriorly and laterally by the pubic symphysis and the ischiopubic rami. Traditionally the urogenital triangle has been divided into two compartments: the superficial and deep perineal spaces, separated by the perineal membrane, which spans the space between the ischiopubic rami.[4] However, more recent studies of this region describe the perineal membrane as a complex structure with many parts. It is composed of two regions: one dorsal and one ventral. The dorsal region consists of bilateral transverse fibrous sheets that attach the lateral wall of the vagina and perineal body to the ischio-pubic ramus. The ventral region is a solid three-dimensional tissue mass in which several structures are embedded. It contains the compressor urethra and the urethrovaginal sphincter muscle of the distal urethra with the urethra and its surrounding connective tissue (Figure 1.3). The ventral margin of this mass is continuous with the insertion of the arcus tendineus fascia pelvis into the pubic bone. The levator ani muscles are attached to the cranial surface of the perineal membrane. The vestibular bulb and clitoral crus lie on the caudal surface of the membrane and are fused with it, there being no natural plane of cleavage between these erectile structures and the membrane. Therefore, the structure of the perineal membrane is not a trilaminar sheet with perforating viscera, but a complex three-dimensional structure with two distinctly different dorsal and ventral regions.[5]

Just beneath the skin of the anterior perineum lies the superficial perineal fascia (Colles' fascia). As described above, the erectile tissues are fused to the caudal surface of the perineal membrane complex. The erectile tissues are covered by the bulbospongiosus and the ischiocavernosus muscles. The superficial transverse perineal muscles attach the perineal body to the ischial tuberosities bilaterally. All of these perineal muscles are innervated by a branch of the pudendal nerve, which is a mixed motor and sensory nerve.

1.3.1.1 Superficial Transverse Perineal Muscle

The superficial transverse muscle is a narrow slip of a muscle, which arises from the inner and forepart of the ischial tuberosity and is inserted into the central tendinous part of the perineal body (Figure 1.2a). The muscle from the opposite side, the EAS from behind, and the bulbospongiosus in the front all attach to the central tendon of the perineal body.[4]

1.3.1.2 Bulbospongiosus Muscle

The bulbospongiosus muscle runs on either side of the vaginal orifice, covering the lateral aspects of the vestibular bulb anteriorly and the

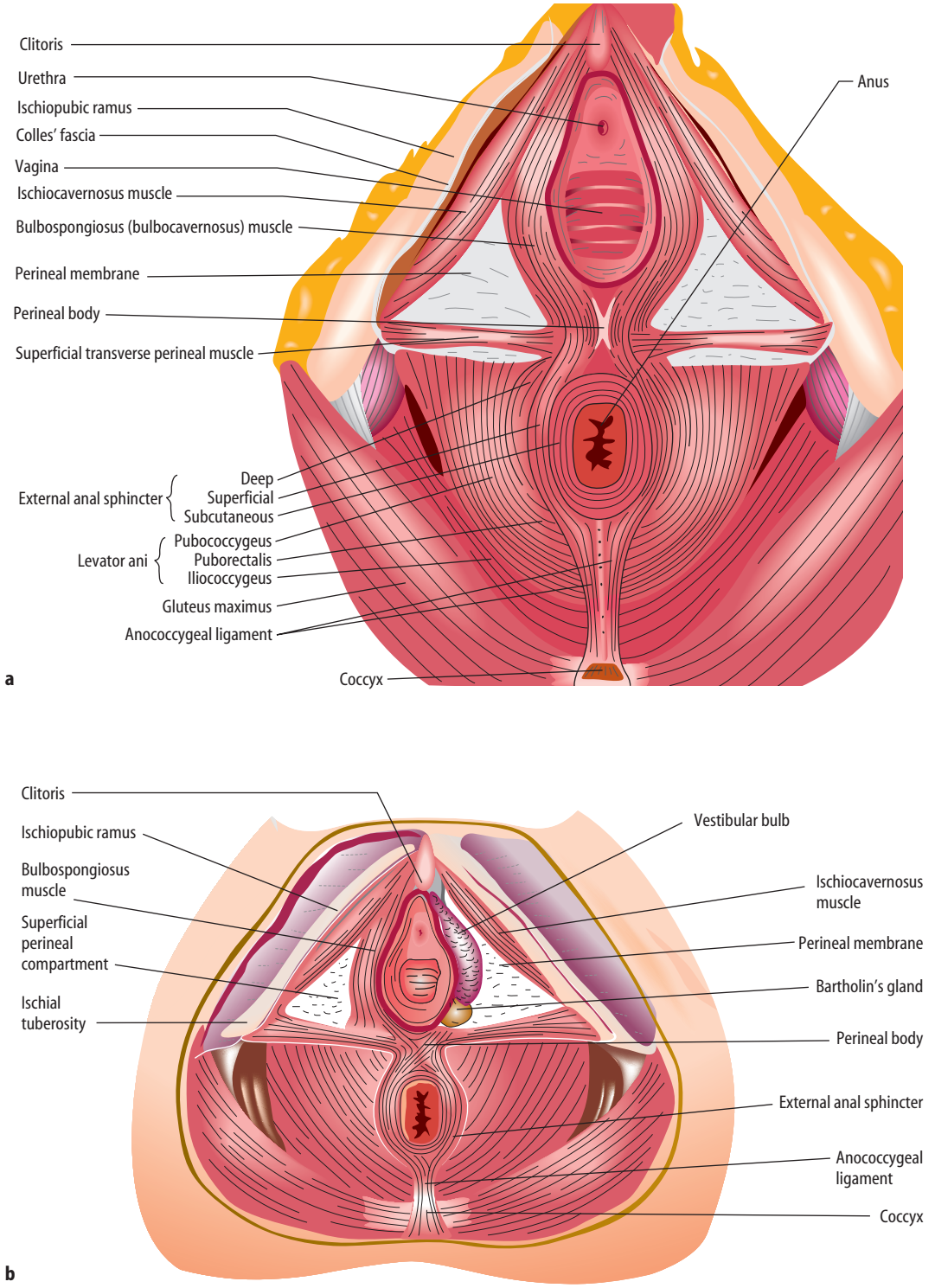

Figure 1.2. The superficial compartment contains the superficial transverse perineal muscle, the bulbospongiosus and the ischiocavernosus. These three muscles form a triangle on either side of the perineum, with a floor formed by the perineal membrane. (a) The left bulbospongiosus muscle has been removed to demonstrate the vestibular bulb and bartholin's gland (b).

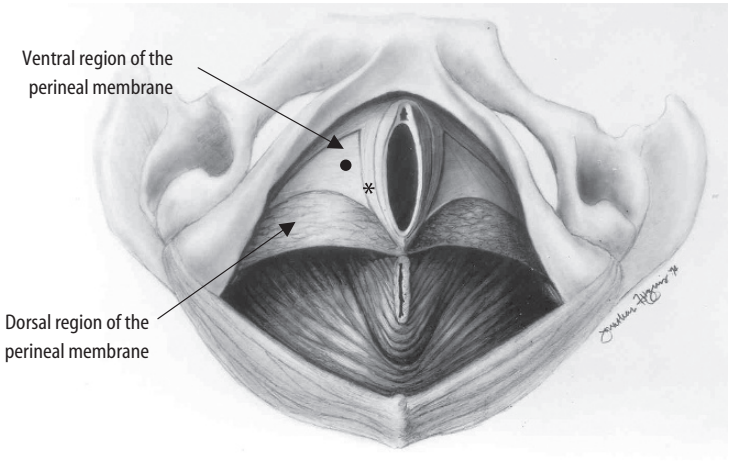

Figure 1.3. The perineal membrane. Position of the perineal membrane with the erectile tissues (clitoral cura and vestibular bulbs) removed and the associated components of the striated urogenital sphincter and the urethrovaginal sphincter * and the compressor urethra •. (© Delancey, with permission.)

Bartholin's gland posteriorly (Figure 1.2b). Some fibres merge posteriorly with the superficial transverse perineal muscle and the EAS in the central fibromuscular perineal body. Anteriorly, its fibres pass forward on either side of the vagina and insert into the corpora cavernosa clitoridis, a fasciculus crossing over the body of the organ so as to compress the deep dorsal vein. This muscle diminishes the orifice of the vagina and contributes to the erection of the clitoris.

1.3.1.3 Ischiocavernosus Muscle

The ischiocavernosus muscle is elongated, broader at the middle than at either end, and is situated on the side of the lateral boundary of the perineum (Figure 1.2a). It arises by tendinous and fleshy fibres from the inner surface of the ischial tuberosity, behind the crus clitoridis, from the surface of the crus and from the adjacent portions of the ischial ramus. The ischiocavernosus compresses the crus clitoridis, retards blood flow through the veins, and thus serves to maintain erection of the clitoris.

1.3.2 The Anal Triangle

This area includes the anal canal, the anal sphincters, and ischioanal fossae.

1.3.2.1 Anal Canal

The rectum terminates in the anal canal (Figure 1.4a, b). Definitions of the anal canal vary among surgeons and anatomists.[6] The surgical anal canal is approximately 4 cm long and extends from the anal verge to the anorectal ring, which is defined as the proximal level of the levator–EAS complex.[7] This clinical description correlates with a digital or sonographic examination but does not correspond to the histological architecture.[8] The embryological anal canal extends from the anal valves (see below) to the anal margin and is approximately 2 cm long.[2]

The anal canal is attached posteriorly to the coccyx by the anococcygeal ligament, a midline fibromuscular structure, which runs between the posterior aspect of the EAS and the coccyx (Figure 1.2). The anus is surrounded laterally and posteriorly by loose adipose tissue within the ischioanal fossae, which is a potential pathway for spread of perianal sepsis from one side to the other. The pudendal nerves pass over the ischial spines at this point (Figure 1.5) and can be accessed digitally at this site for measurement of the pudendal nerve terminal motor latency using a modified electrode[9] (see Chapter 9). The perineum can also be anaesthetised by injection of local anaesthetic into the pudenal nerve at this site. Anteriorly, the perineal body separates the anal canal from the vagina.

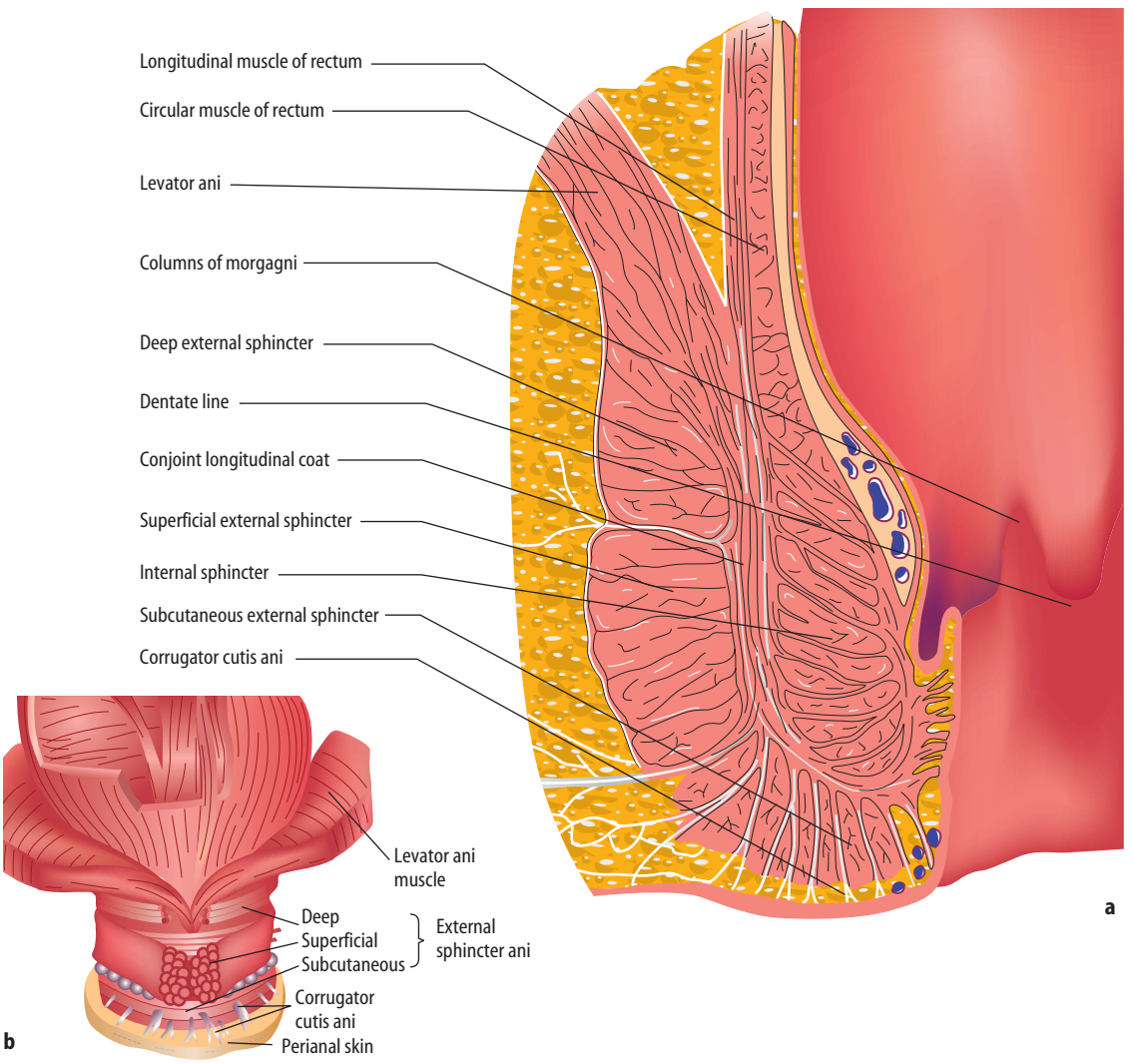

FIGURE 1.4. **a** Coronal section of the anorectum. **b** Anal sphincter and levator ani.

The anal canal is surrounded by an inner epithelial lining, a vascular subepithelium, internal anal sphincter (IAS), EAS and fibromuscular supporting tissue. The lining of the anal canal varies along its length due to its embryologic derivation. The proximal anal canal is lined with rectal mucosa (columnar epithelium) and is arranged in vertical mucosal folds called the columns of Morgagni (Figure 1.4a). Each column contains a terminal radical of the superior rectal artery and vein. The vessels are largest in the left-lateral, right-posterior and right-anterior quadrants of the wall of the anal canal where the subepithelial tissues expand into three *anal cushions*. These cushions seal the anal canal and help maintain continence of flatus and liquid stools. The columns are joined together at their inferior margin by crescentic folds called anal valves.[2] About 2 cm from the anal verge, the anal valves create a demarcation called the dentate line. Anoderm covers the last 1–1.5 cm of the distal canal below the dentate line and consists of modified squamous epithelium that lacks skin adnexal tissues such as hair follicles and glands, but contains

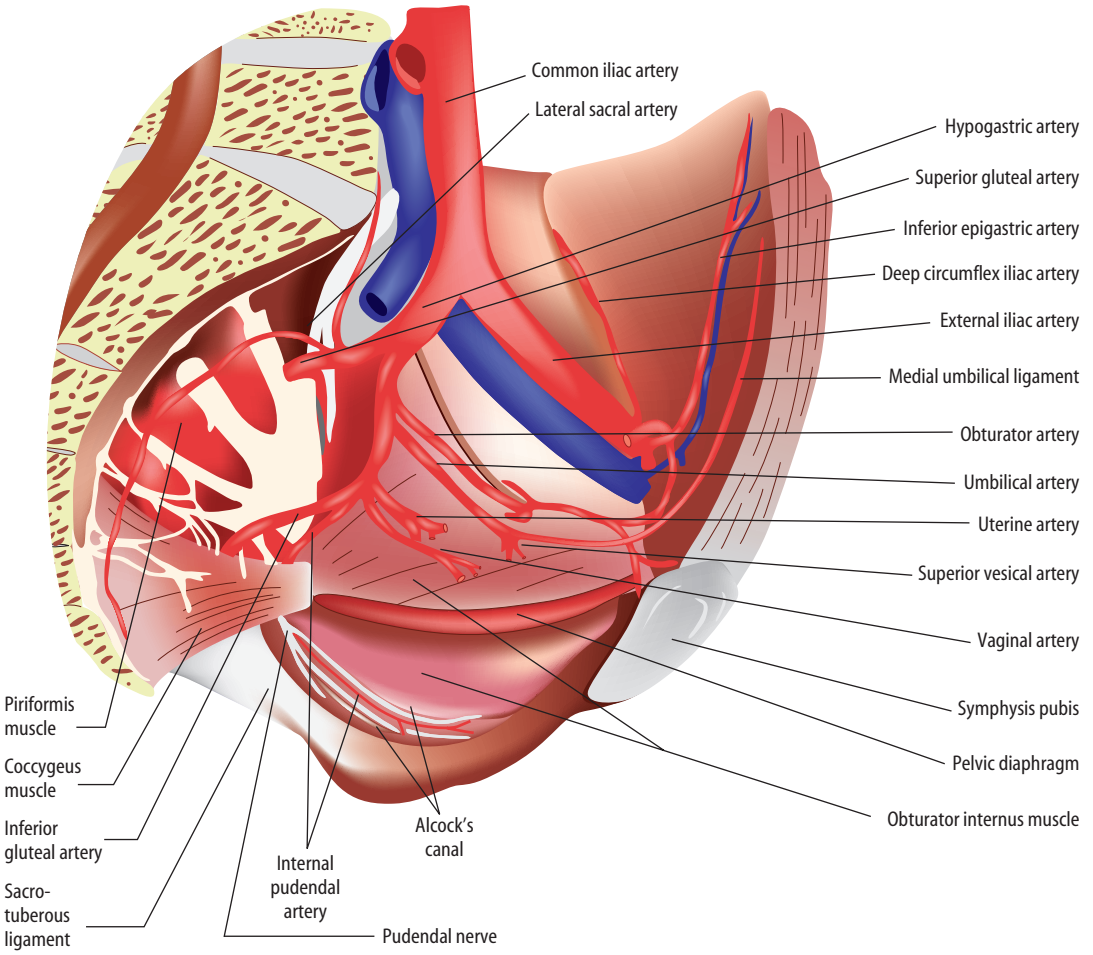

Figure 1.5. Saggital view of the pelvis demonstrating the pathway of the pudendal nerve and blood supply.

numerous somatic nerve endings. Since the epithelium in the lower canal is well supplied with sensory nerve endings, acute distension or invasive treatment of haemorrhoids in this area causes profuse discomfort, whereas treatment can be carried out with relatively few symptoms in the upper canal lined by insensate columnar epithelium.[9] As a result of tonic circumferential contraction of the sphincter, the skin is arranged in radiating folds around the anus and is called the anal margin.[8] These folds appear to be flat or ironed out when there is underlying sphincter damage. The junction between the columnar and squamous epithelia is referred to as the anal transitional zone, which is variable in height and position and often contains islands of squamous epithelium extending into columnar epithelium. This zone probably has a role to play in continence by providing a highly specialised sampling mechanism (see Chapter 8).

1.3.2.2 Anal Sphincter Complex

The anal sphincter complex consists of the EAS and IAS separated by the conjoint longitudinal coat (Figure 1.4a). Although they form a single unit, they are distinct in structure and function.

External Anal Sphincter

Structurally, the EAS (Figure 1.4a) is subdivided into three parts: the subcutaneous, superficial and

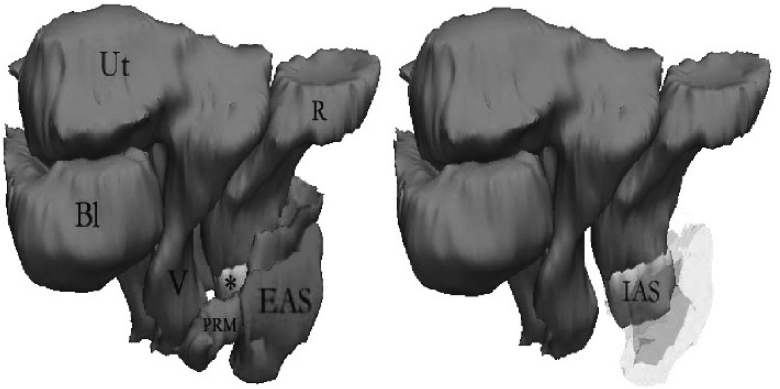

Figure 1.6. Computer reconstruction demonstrating the anal sphincter complex: external anal sphincter (*EAS*), puborectalis muscle (*PRM*) and internal anal sphincter (*IAS**). *Bl* Bladder, *Ut* uterus, *V* vagina, *R* rectum.

deep.[10] However, these subdivisions are not easily demonstrable during anatomical dissection or surgery, but may be of relevance during imaging (see Chapter 10). In females, the EAS is shorter anteriorly (Figure 1.6).[11] The deep EAS is intimately related to the puborectalis muscle and does not have posterior attachments.[12] The superficial EAS is attached posteriorly to the anococcygeal ligament, which is attached to the tip of the coccyx.[9] The subcutaneous part is circular but may have attachments to the perineal body anteriorly and the anococcygeal ligament posteriorly. In females, the bulbospongiosus and the transverse perineii fuse with the EAS in the lower part of the perineum.[9]

Internal Anal Sphincter

The IAS is a thickened continuation of the circular smooth muscle of the bowel and ends with a well-defined rounded edge 6–8 mm above the anal margin at the junction of the superficial and subcutaneous part of the EAS (Figure 1.4a). In contrast to the EAS, the IAS has a pale appearance to the naked eye.

The Longitudinal Layer and the Conjoint Longitudinal Coat

The longitudinal layer is situated between the EAS and IAS and consists of a fibromuscular layer, the conjoint longitudinal coat and the intersphincteric space with its connective tissue components[13] (Figure 1.4a). The longitudinal layer has a muscular and fibroelastic component. The muscular component is formed by the fusion of the striated muscle fibres from the puboanalis, the innermost part of the puborectalis with smooth muscle from the longitudinal muscle of the rectum.[9] Traced downwards, it separates opposite the lower border of the IAS and the fibrous septae fan out to pass through the EAS and ultimately attach to the skin of the lower anal canal and perianal region.[10]

1.3.2.3 Innervation of the Anal Sphincter Complex

As the IAS is a continuation of the circular fibres of the rectum, it shares the same innervation: sympathetic (L5) and parasympathetic nerves (S2–S4). It remains in a state of tonic contraction and accounts for 50–85% of the resting tone.[7] The conjoint longitudinal coat is innervated by autonomic fibres from the same origin. The EAS is innervated by the inferior rectal branch of the pudendal nerve. In contrast to the other striated muscles, the EAS contributes up to 30% of the unconscious resting tone through a reflex arc at the cauda equine level.

1.3.2.4 Vascular Supply

The anorectum receives its major blood supply from the superior (terminal branch of the inferior mesenteric artery) and inferior haemorrhoidal (branch of the pudendal artery) arteries, and to a lesser degree, from the middle haemorrhoidal artery (branch of the internal iliac), forming a

wide intramural network of collaterals.[14] The venous drainage of the upper anal canal mucosa, IAS and conjoint longitudinal coat passes via the terminal branches of the superior rectal vein into the inferior mesenteric vein. The lower anal canal and the EAS drain via the inferior rectal branch of the pudendal vein into the internal iliac vein.[9]

1.3.2.5 Lymphatic Drainage

The anorectum has a rich network of lymphatic plexuses. The dentate line represents the interface between the two different systems of lymphatic drainage. Above the dentate line (the upper anal canal), the IAS and the conjoint longitudinal coat drain into the inferior mesenteric and internal iliac nodes. Lymphatic drainage below the dentate line, which consists of the lower anal canal epithelium and the EAS, proceeds to the external inguinal lymph nodes.

1.3.2.6 Ischioanal Fossa

The ischioanal fossa (previously known as the "ischiorectal fossa") extends around the anal canal and is bound anteriorly by the perineal membrane, superiorly by the fascia of the levator ani muscle and medially by the EAS complex at the level of the anal canal. The lateral border is formed by the obturator fascia and inferiorly by a thin transverse fascia, which separates it from the perianal space. The ischioanal fossa contains fat and neurovascular structures, including the pudendal nerve and the internal pudendal vessels, which enter through Alcocks's canal.[8]

1.4 Perineal Body

The perineal body is the central point between the urogenital and the anal triangles of the perineum (Figure 1.2). Its three-dimensional form has been likened to that of the cone of the red pine, with each "petal" representing an interlocking structure, such as an insertion site of fascia or a muscle of the perineum.[15] Within the perineal body there are interlacing muscle fibres from the bulbospongiosus, superficial transverse perineal, and EAS muscles. Above this level there is a contribution from the conjoint longitudinal coat and the medial fibres of the puborectalis muscle. Therefore, the support of the pelvic structures, and to some extent the hiatus urogenitalis between the levator ani muscles, depends upon the integrity of the perineal body.

1.5 The Pelvic Floor

The pelvic floor (pelvic diaphragm) is a musculotendineous sheet that spans the pelvic outlet and consists mainly of the symmetrically paired levator ani (Figure 1.7). The fasciae investing the muscles are continuous with visceral pelvic fascia above, perineal fascia below, and obturator fascia laterally. The pelvic floor supports the urogenital organs and the anorectum, exiting the pelvis through their respective foramen. The muscles of the levator ani differ from most other skeletal muscles in that they: (1) maintain constant tone, except during voiding, defaecation and the Valsalva manoeuvre; (2) have the ability to contract quickly at the time of acute stress (such as a cough or sneeze) to maintain continence; and (3) distend considerably during parturition to allow the passage of the term infant and then contract after delivery to resume normal functioning.[16]

The levator ani (Figure 1.7) is a broad muscular sheet of variable thickness attached to the internal surface of the true pelvis and is subdivided into parts according to their attachments and pelvic viscera to which they are related, namely iliococcygeus, pubococcygeus and ischiococcygeus.[4] Although referred to as separate muscles, the boundaries between the different parts cannot be easily distinguished and they perform many similar physiological functions.

The ischiococcygeus part (sometimes named coccygeus) may be considered as a separate muscle. It is a narrow triangular sheet of muscular and tendinous fibres, its apex arising from the spine of the ischium and sacrospinous ligament, and its base inserting into the margin of the coccyx and into the side of the lowest piece of the sacrum. It assists the levator ani and piriformis in closing in the back of the pelvic outlet.

The iliococcygeus muscle is the lateral component of the levator ani muscle and arises from the ischial spine below and anterior to the attachment of the ischiococcygeus and to the obturator fascia as far forward as the obturator canal. The most

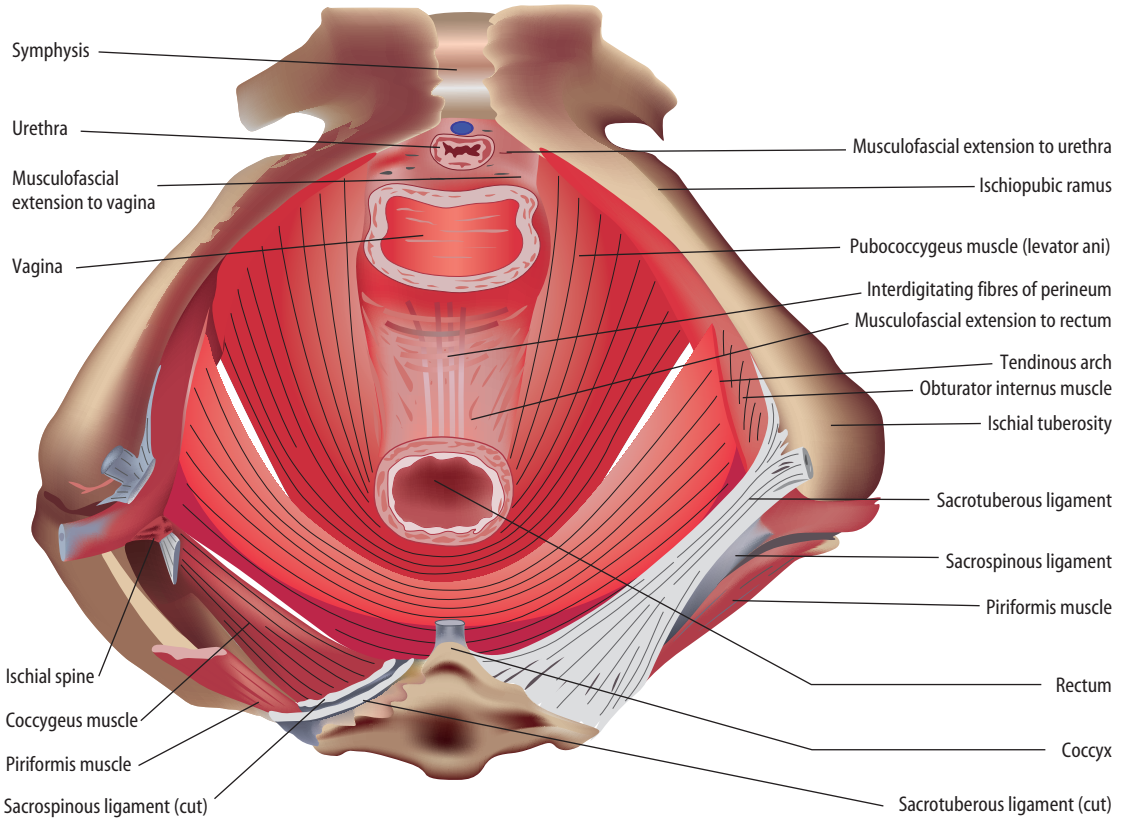

Figure 1.7. The levator ani muscles viewed from below.

posterior fibres are attached to the coccyx and the sacrum, but most join with fibres from the opposite side to form a raphe, which is more or less continuous with the fibroelastic anococcygeal ligament, and is attached to the coccyx and anococcygeal raphe. The pubococcygeus arises from the back of the pubis and from the anterior part of the obturator fascia, and is directed backward almost horizontally along the side of the anal canal toward the coccyx and sacrum, to which it finds attachment. The greater part of this muscle is inserted into the coccyx and into the last one or two pieces of the sacrum. The pubococcygeus is often subdivided into separate parts according to the pelvic viscera to which they relate (i.e. pubourethralis and puborectalis in the male, pubovaginalis and puborectalis in the female). The most medial fibres of the pubococcygeus form a sling around the rectum and are named the puborectalis. The puborectalis is the most caudal component of the levator ani complex. It is situated cephalad to the deep component of the EAS, from which it is almost inseparable (Figures 1.4a, b, 1.6). Thus the puborectalis serves both functions: as part of the sphincter mechanism and the pelvic floor. The U-shaped sling of striated muscle pulls the anorectal junction anteriorly to the posterior aspect of the pubis,[7] resulting in an angulation between the rectal and anal canal called the anorectal angle. There is considerable controversy as to the importance of this angle in the maintenance of continence.[17] Between the two arms of the puborectalis lies the levator hiatus, through which the rectum, vagina and urethra pass.

In the female, the anterior fibres of the levator ani descend upon the side of the vagina. These fibres have been called the puboperineal muscle and appear to undergo the greatest stretch during vaginal delivery. They have been found to be damaged in women with urinary incontinence and pelvic organ prolapse following delivery.[18]

1.5.1 Innervation of the Levator Ani

Although widely believed that the levator ani is supplied on its superior surface by the sacral nerve roots (S2–S4) and on its inferior surface by the perineal branch of the pudendal nerve, recent cadaveric dissections along with nerve staining studies have shown that the female levator ani is not innervated by the pudendal nerve, but rather by innervation that originates in the sacral nerve roots (S3–S5) and travels on the superior surface of the pelvic floor (levator ani nerve).[16]

The most common arrangement appears to be that the pubococcygeus is supplied by second and third sacral spinal segments via the pudendal nerve, and the ischiococcygeus and iliococcygeus by direct branches from third and fourth sacral spinal segments.[4]

1.5.2 Vascular Supply

The levator ani is supplied by branches of the inferior gluteal artery, the inferior vesical artery and the pudendal artery.

1.6 The Pudendal Nerve

The pudendal nerve derives its fibres from the ventral branches of the second, third and fourth sacral nerves and leaves the pelvis through the lower part of the greater sciatic foramen (Figure 1.5). It then crosses the ischial spine and re-enters the pelvis through the lesser sciatic foramen. It accompanies the internal pudendal vessels upward and forward along the lateral wall of the ischioanal fossa, contained in a sheath of the obturator fascia termed Alcock's canal (Figure 1.5). It is presumed that during a prolonged second stage of labour, the pudendal nerve is vulnerable to stretch injury due to its relative immobility at this site.

The inferior haemorrhoidal (rectal) nerve then branches off posteriorly from the pudendal nerve to innervate the EAS (Figure 1.8). The pudendal nerve then divides into two terminal branches: the perineal nerve and the dorsal nerve of the clitoris. The perineal nerve, the inferior and larger of the two terminal branches of the pudendal, is located

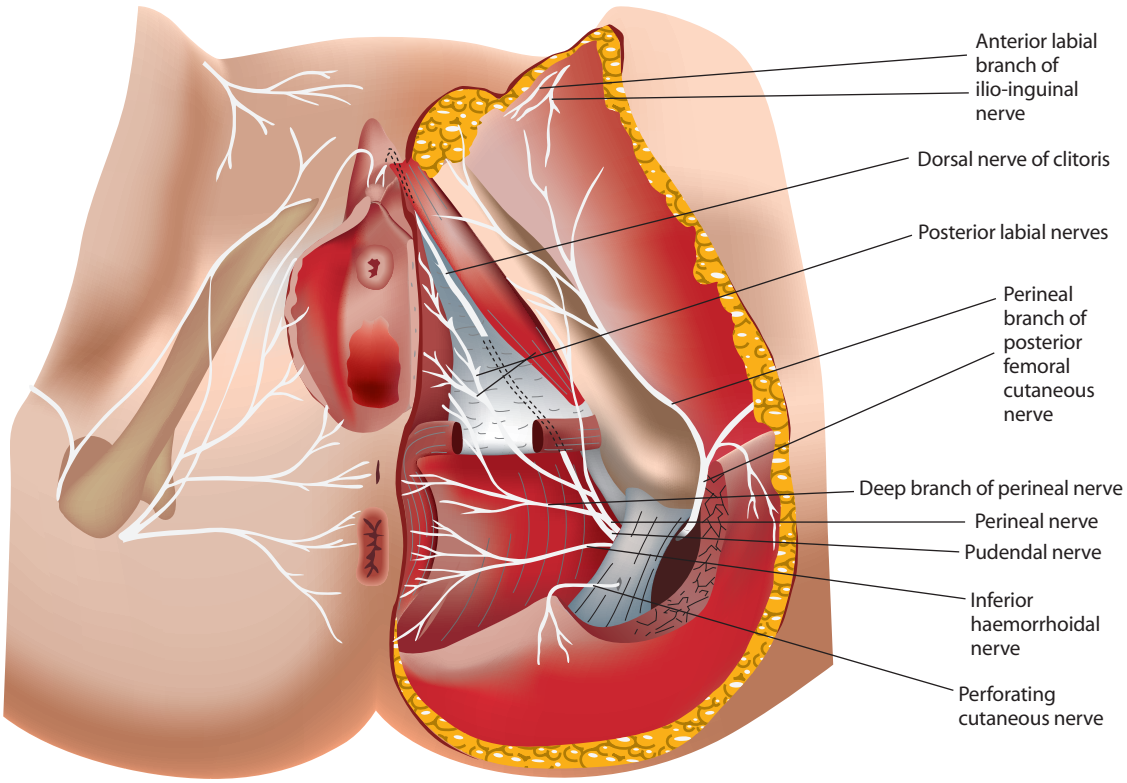

Figure 1.8. Terminal branches of the pudendal nerve.

below the internal pudendal artery. It divides into posterior labial and muscular branches. The posterior labial branches supply the labium majora. The muscular branches are distributed to the superficial transverse perineal, bulbospongiosus, ischiocavernosus and constrictor urethræ muscles. Branches from the perineal division frequently innervate the anterior EAS as well. The dorsal nerve of the clitoris, which supplies the clitoris, is the deepest division of the pudendal nerve (Figure 1.8).

1.7 Conclusion

An understanding of the anatomy of the pelvic floor, anal sphincters and perineum is essential for health care providers caring for women during and after vaginal delivery. Proper perineal and sphincter repair requires clear visualisation of the structures of the perineal body and sphincter muscles. When trauma occurs, the practitioner must be aware of the relationships between nerves, muscles and vessels in order to restore at best, normal anatomy and function.

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