Anatomy of the lower urinary tract

Vishy Mahadevan

Abstract

For descriptive purposes the urinary tract is divided into two parts: the upper urinary tract and the lower urinary tract. The former comprises the kidneys and ureters, while the lower urinary tract consists of the urinary bladder and the urethra. In this article, a detailed description of the surgical and functional anatomy of the urinary bladder is followed by a description of the clinical anatomy of the female and male urethra. There then follows a brief description of the relevant anatomy of the prostate and seminal vesicles. While not strictly involved in the conduction of urine from the bladder to the exterior, the prostate and seminal vesicles are so intimately related (both topographically and functionally) to the urethra and bladder that no account of the lower urinary tract in the male would be complete without them. It is conventional therefore to regard the prostate and seminal vesicles as part of the lower urinary tract.

Keywords Detrusor; parasympathetic nerves; prostate; seminal vesicle; trigone; urachus; urethra; urinary bladder; urothelium

The urinary bladder

The urinary bladder is a distensible and hollow viscus which functions as a temporary reservoir for the urine that is conveyed to it continuously by the two ureters. It is wholly extraperitoneal. The muscular wall of the bladder confers an impressive degree of contractility to the bladder. The size, shape and position of the bladder and the relationship of the bladder to nearby structures are determined by the degree to which the bladder is distended by the contained urine and also by the state of the adjacent viscera. In the adult, the *empty* urinary bladder lies entirely within the true pelvic cavity, occupying the anterior part of the pelvic cavity, behind the pubic symphysis and pubic bones. As the bladder distends it ascends above the level of the pelvic brim and thus into the abdomen.

It is important, however, to emphasize that in the neonate and infant, the bladder, even when empty, is an abdominal viscus. The explanation for this lies in the fact that at birth there is practically no depth or volume to the pelvic cavity. The bladder neck at this stage lies level with the upper edge of the pubic symphysis. The bladder is almost tubular in shape and lies in contact with the posterior surface of the lower part of the anterior abdominal wall. This anatomical feature is a very important surgical consideration when performing lower abdominal laparotomy incisions in infants. It is only by the age of 7 or 8 years that the pelvic cavity acquires sufficient depth to accommodate the bladder, and it is only at about the time of puberty that the bladder becomes truly intrapelvic in location, and then only when the bladder is empty! When empty the bladder appears flattened from above downwards by the pressure of neighbouring viscera, but as it fills with urine, it assumes an ovoid shape. The empty, contracted adult bladder has a somewhat tetrahedral shape (Figures 1 and 2) and presents externally, four surfaces which are demarcated from each other by indistinct borders: a superior surface, a posterior surface (also referred to as the base of the bladder) and two inferolateral surfaces (right and left) which meet anteriorly. The anterior angle of the superior surface (where the superior surface meets the two inferolateral surfaces) is the apex of the bladder. Running anterosuperiorly from the apex of the bladder to the umbilicus is the median umbilical ligament. The latter is a fibrous, cord-like remnant of the embryological urachus. The bladder neck refers to the lowest part of the bladder where the posterior and inferolateral surfaces of the bladder meet. Within the bladder neck lies the internal urethral orifice through which the bladder lumen is continuous with the urethra. In the male the bladder neck lies immediately above the upper surface (or base) of the prostate. In the female, the bladder neck is related to the pelvic floor and the pelvic fascia surrounding the upper urethra. Posteriorly, the bladder neck is related to the anterior vaginal wall and fornix. With the inflow of urine and progressive distension of the bladder, the vague demarcations between the surfaces of the bladder gradually disappear and the surfaces merge one with another as the bladder assumes a globoid or ovoid shape.

The relationship of the bladder to the peritoneum (Figures 1 and 2) is of considerable surgical and clinical importance. The superior surface of the bladder (also known as the dome of the bladder) is covered completely by peritoneum; the peritoneum is densely attached to this surface. Anteriorly the peritoneum leaves the superior surface of the bladder and stretches upwards to reach the posterior surface of the anterior abdominal wall where it blends with the fascia transversalis. The level at which the peritoneum meets the fascia transversalis lies 4–5 cm superior to the upper edge of the pubic symphysis. Three longitudinal folds, all directed towards the umbilicus, are seen in the peritoneum that sweeps superiorly from the dome of the bladder to the anterior abdominal wall. The central fold is the median umbilical fold. It is produced by the underlying cord-like median umbilical ligament, the obliterated remnant of the urachus. On each side of the median umbilical fold is the corresponding medial umbilical fold produced by the underlying medial umbilical ligament which is the obliterated remnant of the umbilical artery (Figure 3). Laterally on either side, the peritoneum leaves the superior surface of the bladder to reach the obturator fascia (the fascia covering the inner surface of the obturator internus) on the lateral pelvic wall (Figure 3). Posteriorly, in the male, the peritoneum descends from the superior surface of the bladder on to the posterior surface (base of the bladder) for a very short distance before it turns posteriorly to reach the ventral surface of the rectum. The shallow fold of peritoneum thus produced is termed the rectovesical pouch. In the female the peritoneum extends directly backwards onto the uterine isthmus without dipping down the posterior surface of the bladder (see Figure 1).

As the bladder distends with urine it becomes progressively rounded and rises above the pelvic brim into the abdominal cavity, stripping the peritoneum away from the posterior surface

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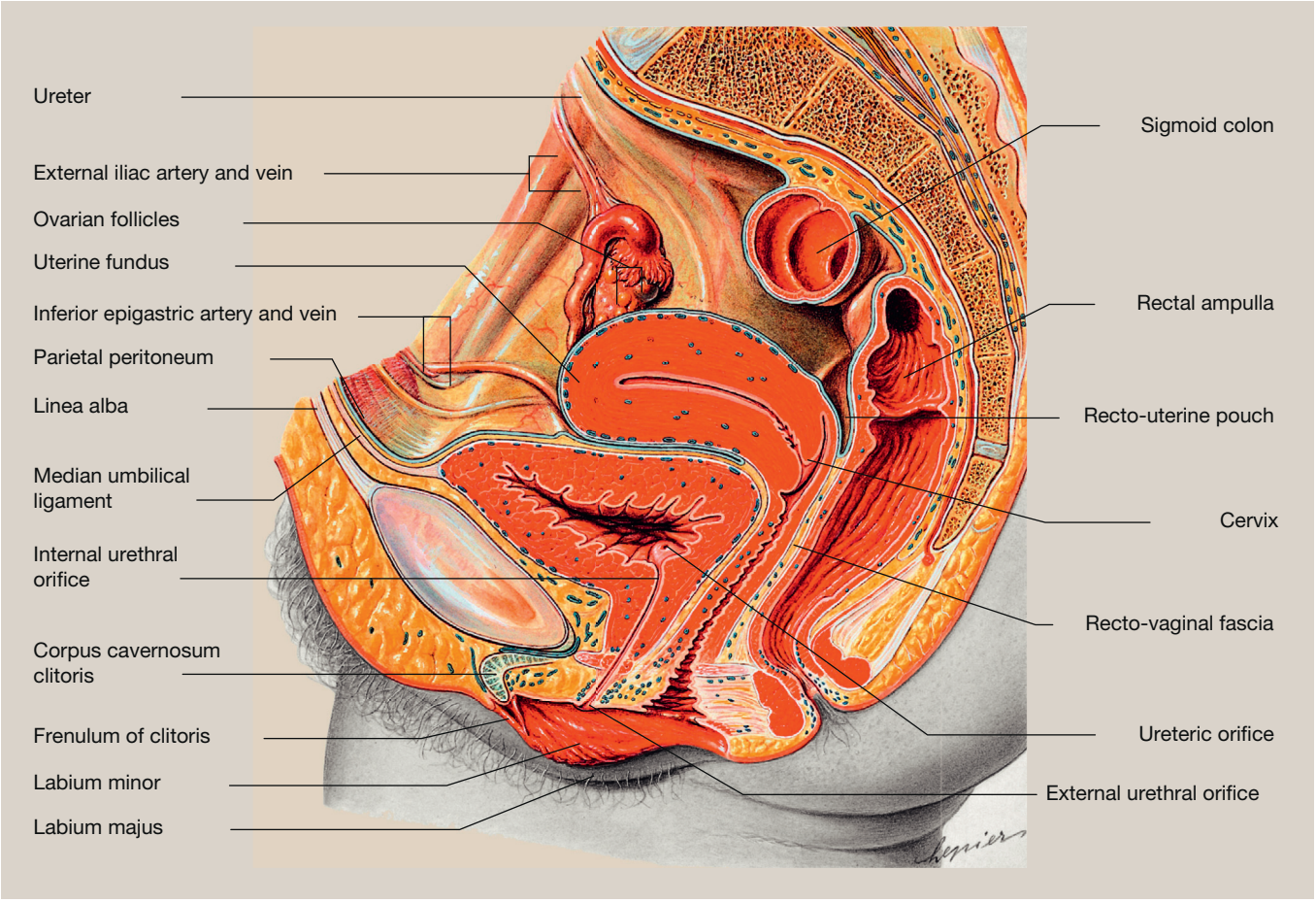

Figure 1 Sagittal view of female pelvic cavity showing relations of urinary bladder and relationship of peritoneum to bladder

of the anterior abdominal wall. The inferolateral surfaces of the bladder now rest directly against the posterior surface of the abdominal wall without any intervening peritoneum. At this stage the distended bladder may be palpable or may be identified and defined by percussion. A needle or cannula advanced perpendicular to the anterior abdominal wall in the anterior midline just above the pubic symphysis will enter the distended bladder without traversing the peritoneal cavity. This is the anatomical basis to suprapubic puncture of bladder, suprapubic catheterization and suprapubic cystostomy. The dome of the urinary bladder is the most mobile and least well-supported of the walls of the bladder. A powerful blunt injury to the lower abdomen in a subject with a tense and distended bladder, may well result in a rupture of the bladder dome. The ensuing leak of urine will inevitably be into the peritoneal cavity on account of the relationship of the peritoneum to the dome. A rupture through any of the other walls of the bladder is likely to result in an extraperitoneal leak of urine. The management of bladder perforations will differ significantly depending on whether the perforation is intra or extraperitoneal.

Interior of the bladder

The inner aspect of the lower part of the posterior wall of the bladder features a triangular area called the trigone. The outline of the trigone is that of an inverted triangle, with the internal urethral orifice at the apex of the triangle and the right and left ureteric orifices marking the other two angles (Figure 4). The two ureteric orifices appear as oblique slits and are about 3 cm apart, in the empty bladder. However, when the bladder is fully distended the distance between the two orifices may be up to 5 cm. Running transversely between the two ureteric orifices is a sub-mucosal ridge termed the interureteric bar (Mercier's bar). The outer wall of the bladder corresponding to trigonal region is firmly fixed to the upper surface of the prostate (in the male) and to the anterior vaginal wall (in the female). This makes the trigone the least mobile part of the bladder. The mucous membrane of the empty bladder is rugose but this rugosity disappears when the bladder is distended with fluid, as is readily observed during cystoscopy. Over the trigone which is the least distensible part of the bladder, the mucous membrane is always smooth. The vesical mucosa is only loosely adherent to the subjacent detrusor muscle. However, in the region of the trigone, the mucosa is more densely adherent to the subjacent muscle. The entire urinary bladder is lined on the inside by a specialized epithelium termed urothelium (synonymous with transitional epithelium). This epithelium is unique to the conducting part of the urinary tract and forms an uninterrupted and complete inner lining of the entire pelvicalyceal system of the kidneys, the ureters, the urinary bladder and the proximal urethra.

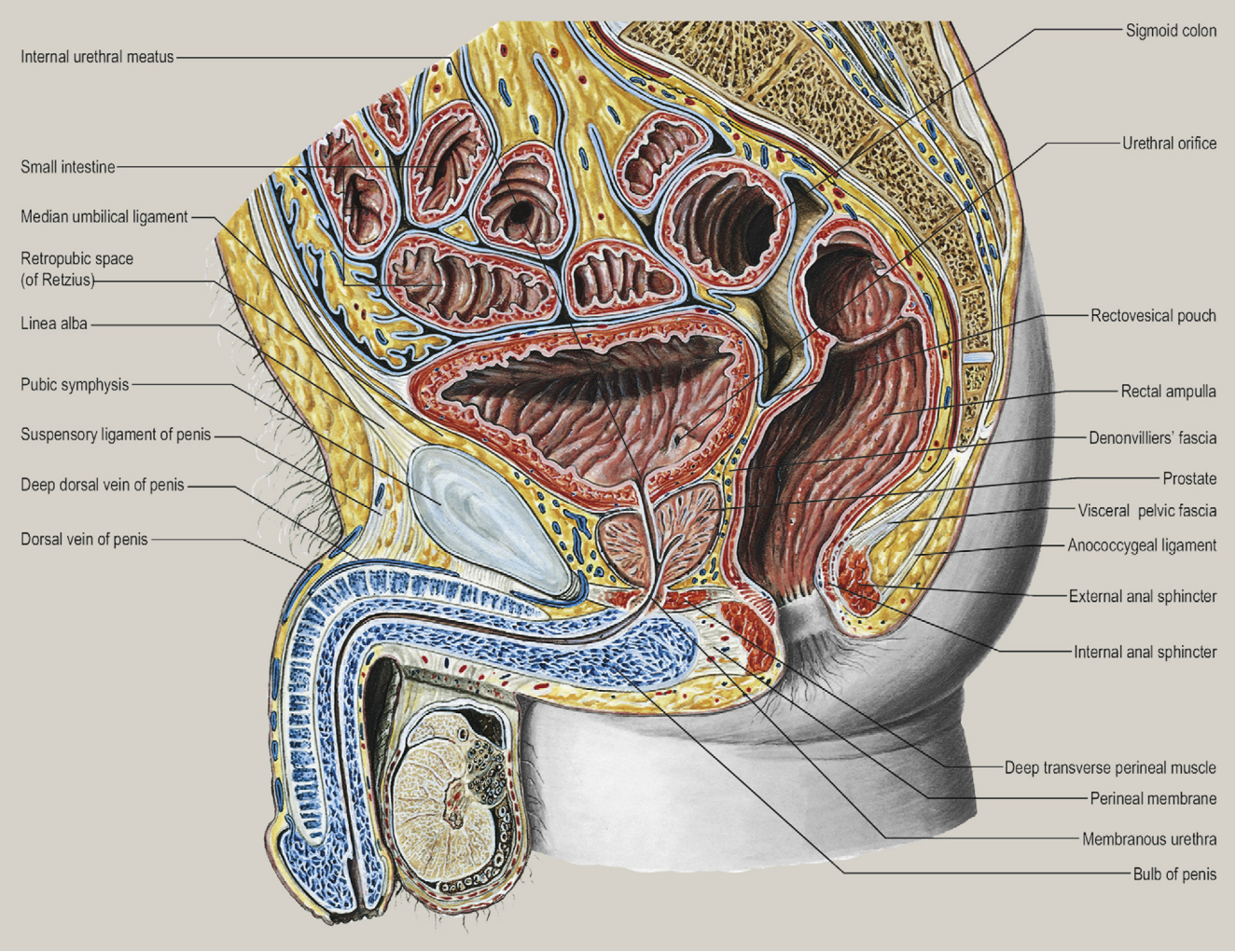

Figure 2 Sagittal view of male pelvic cavity showing relations of urinary bladder and the various segments of the urethra.

Topographical relations of the urinary bladder

The anterior and inferolateral topographical relations of the bladder are similar in the two sexes. However, posteriorly, superiorly and inferiorly the relations of the bladder are strikingly different in the two sexes. Superiorly, lying on the peritoneal covering of the bladder dome are loops of small intestine and occasionally a segment of a particularly tortuous sigmoid colon. In the female the upper surface of the bladder is often overlapped by an anteverted uterus (see Figure 1). Inferolaterally, on either side, the bladder wall is related to the ipsilateral obturator internus and levator ani muscles being separated from these muscles by loose connective tissue. It is through this connective tissue that blood vessels and lymphatic vessels reach the bladder. Anteriorly, the bladder neck and the anterior aspect of the bladder wall (where the two inferolateral surfaces meet) are related to the retropubic space, a fat-filled space which contains a plexus of veins. The immediate posterior relations of the bladder in the female are the anterior wall of the vagina and the anterior vaginal fornix, the anterior surface of the supravaginal cervix and body of uterus. The posterior surface of the bladder is firmly attached by connective tissue to these structures (see Figure 2). In the male, applied to the posterior surface of the bladder on each side of the midline, are the corresponding seminal vesicles and the terminal portions of the vas deferens and ureter (see Figure 3). Inferiorly, the bladder neck continues directly into the urethra. In the female the latter is seen to be embedded in the anterior wall of the vagina, and together these structures traverse the levator hiatus (the midline gap in the pelvic floor through which pelvic structures cross over into the perineum). In the male, the inferior aspect of the bladder lies immediately above the upper surface of the prostate.

Blood supply and venous and lymphatic drainage of the urinary bladder

Arterial supply: the urinary bladder derives its blood supply exclusively from the right and left internal iliac arteries which make a more-or-less equal and symmetrical contribution. The anterior division of each internal iliac artery gives rise to a superior and an inferior vesical artery. These are the principal arteries of supply to the bladder. The former supplies the anterior and superior aspects of the bladder, while the inferior vesical artery supplies the posterior and inferior aspects of the bladder, including the bladder neck. The obturator and inferior gluteal arteries both of which are branches of the internal iliac artery

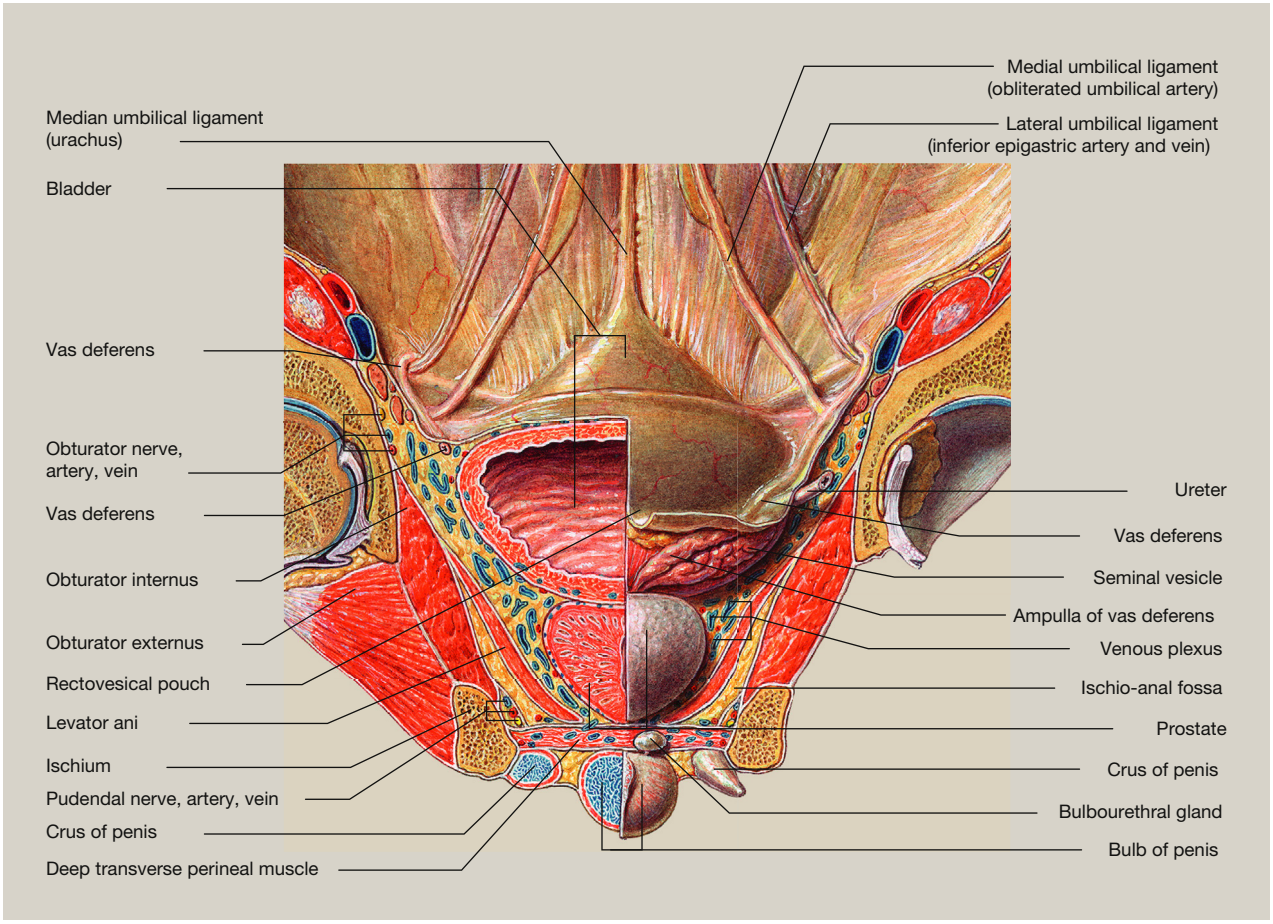

Figure 3 Coronal view of male pelvic cavity (viewed from behind) showing lateral and inferior relations of urinary bladder, and relationship of peritoneum to the bladder.

make a minor contribution to the blood supply of the inferior part of the bladder. In the female the uterine and vaginal arteries contribute to the blood supply of the inferior part of the bladder; the vaginal artery not infrequently giving rise to the inferior vesical artery.

Venous drainage: the veins draining the urinary bladder initially form a rich, delicate plexus circumferentially around the lower part of the bladder (see Figures 2 and 3). This is termed the perivesical venous plexus. It lacks valves. In the male the perivesical plexus is continuous with the extracapsular peri-prostatic venous plexus that is related to the anterior and lateral aspects of the prostate, and in the female it is continuous with the venous plexus that surrounds the intra-pelvic vagina and venous plexus that lies at the base of the broad ligament of the uterus. Emerging from the perivesical venous plexus are venous channels which coalesce to form larger veins which accompany the vesical arteries and eventually drain into the internal iliac veins bilaterally.

Lymphatic drainage: much of the lymphatic drainage of the urinary bladder is by lymphatic vessels which travel laterally and upwards across the pelvic brim to the external iliac and common iliac lymph nodes, bilaterally. Additionally, many lymphatic vessels draining the bladder, accompany the arteries which supply the bladder and drain their contained lymph into the internal iliac lymph nodes, bilaterally.

Support and stability of the bladder

The upper part of the bladder is relatively free and mobile in the extraperitoneal tissue of the pelvic cavity. However, the lower part of the bladder wall and the subjacent bladder neck are firmly anchored to the walls of the pelvic cavity by various condensations of connective tissue. On each side the bladder is supported by a lateral ligament of the bladder. This is a condensation of fibrous tissue that is attached to the side of the bladder neck medially, and stretches across to the tendinous arch of the pelvic fascia, laterally. Anterosuperiorly, the bladder is stabilized by the median umbilical ligament which runs from the apex of the bladder to the umbilicus (see Figure 3). Anteriorly the bladder is separated from the posterior surface of the symphysis pubis and pubic bones by the fat-filled retropubic space (cave of Retzius). The anterior aspect of the bladder neck is firmly anchored to the posterior surfaces of the pubic bones by the pubovesical and pubourethral ligaments in the female, and by the pubovesical and puboprostatic ligaments in the male. These

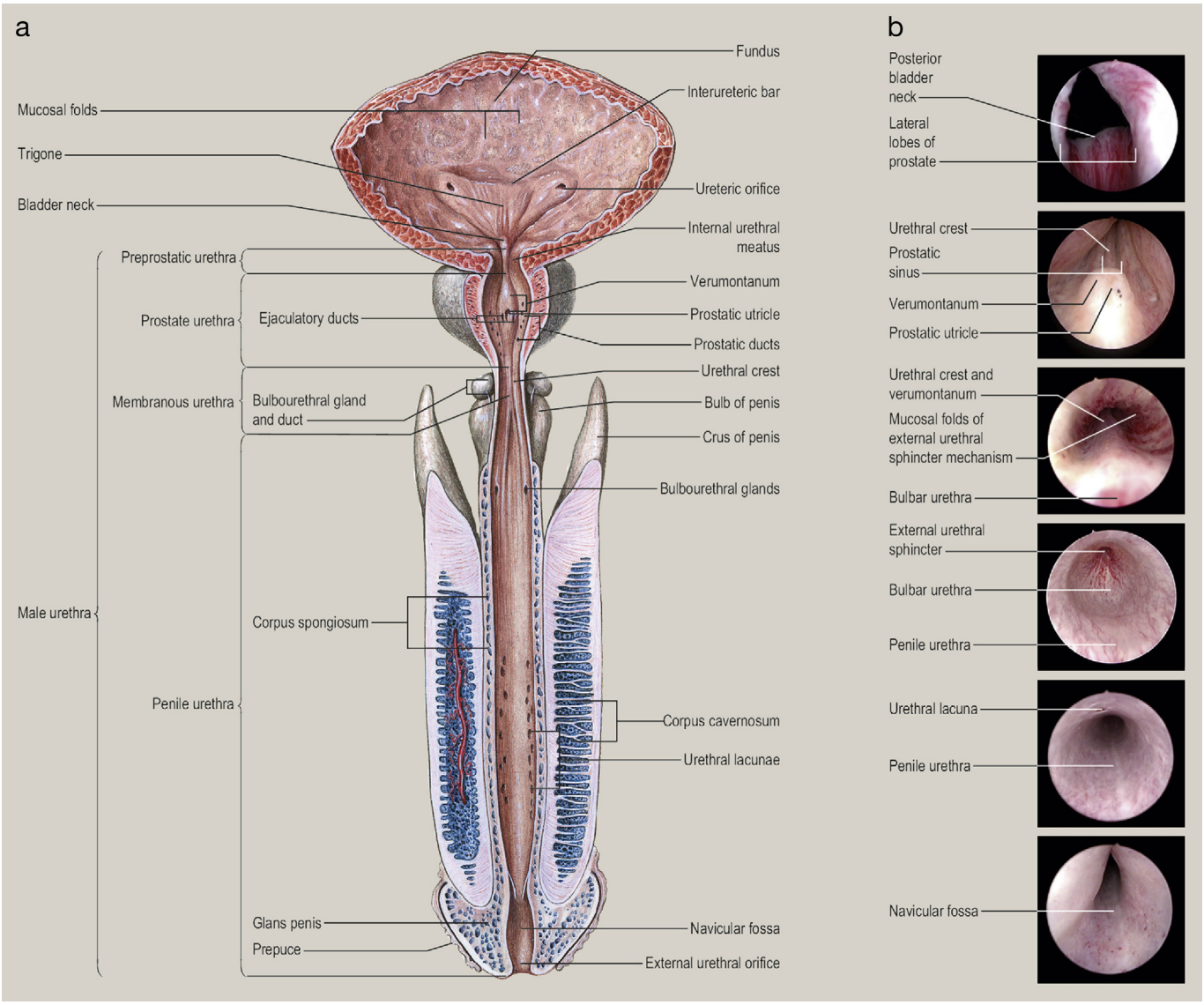

Figure 4 Longitudinal view of urinary bladder and urethra in the male.

ligaments are stout bands of fibrous or fibromuscular tissue which traverse the retropubic space as they extend anteriorly from the bladder neck to the back of the pubis.

Microstructure of the bladder wall: histologically the bladder wall may be said to consist of four layers. From within outwards these are; an inner lining of urothelium; lamina propria; a muscular layer made up of the detrusor muscle and the serosa. The urothelium is a layer of stratified epithelial cells, 3–6 cells thick. Within the urothelium the cells are arranged in three zones or layers: a basal zone, an intermediate zone and a superficial zone – the latter being adjacent to the bladder lumen. The superficial zone forms an impermeable and protective layer for the underlying layers.

The lamina propria is a supporting layer of connective tissue that contains capillaries, lymphatic vessels and neuroreceptors. It is demarcated from the urothelium by a distinct basement membrane. The muscular layer made up of the detrusor muscle. The detrusor muscle is an interlacing network of multi-directional smooth muscle fibres that produce a trabeculated appearance on gross inspection. The detrusor is richly supplied by parasympathetic, cholinergic fibres and is responsible for the contractility of the bladder.

In the trigonal region, however, the musculature consists of two histologically and biochemically distinct muscle layers: an outer layer of parasympathetically innervated detrusor muscle fibres and an inner layer of smooth muscle that is sympathetically innervated by noradrenergic fibres. The inner layer of muscle is termed the superficial trigonal muscle.

The serosa forms a partial covering for the bladder being related only to the dome of the bladder. The serosa is lined externally by mesothelium. Other surfaces of the bladder are covered by a thin layer of non-serosal fibro-fatty connective tissue.

Innervation of the urinary bladder

The nerve fibres supplying the urinary bladder emerge from the right and left inferior hypogastric plexuses, also known as pelvic plexuses. Each inferior hypogastric plexus is a mixed autonomic nerve plexus and contains both sympathetic and parasympathetic components, each carrying both efferent and afferent fibres. The sympathetic fibres reach the plexus via the right and left superior hypogastric nerves (which, in turn are derived from the superior hypogastric plexus) while the parasympathetic fibres reach the plexus by the pelvic splanchnic nerves which emerge from the anterior sacral foramina. The parasympathetic fibres in the inferior hypogastric plexus originate in the 2nd, 3rd and 4th sacral segments of the spinal cord, while the sympathetic fibres which innervate the bladder originate in the spinal cord segments T11 to L2. The inferior hypogastric plexus is an elongated, neural mesh 5–7 cm long, situated lateral to the rectum, internal genitalia and bladder neck. It provides all the parasympathetic and most of the sympathetic innervation to the pelvic and perineal viscera.

Much of the distressing morbidity associated with radical pelvic surgery for cancers of the rectum, prostate and cervix uteri is due to disruption of these important plexuses, and manifests as bladder dysfunction in both sexes and as erectile and/or ejaculatory dysfunction in males. The parasympathetic fibres provide the main motor innervation of the detrusor muscle. However, the sympathetic fibres provide the motor innervation for part of the trigonal musculature (superficial trigonal muscle) and, in the male, the pre-prostatic genital sphincter (described below). The sensation of bladder distension is received by the stretch receptors in the lamina propria and is carried in the parasympathetic fibres to the posterior column of the spinal cord. However, the sensation of pain associated with inflammation of the bladder lining due to a bladder calculus or due to urinary tract infections is carried both by sympathetic and parasympathetic fibres to the lateral spinothalamic tract.

The urethra

The urethra is a channel that connects the urinary bladder to the exterior. It commences at the internal urethral orifice in the bladder neck and ends at the external urethral orifice. In the female the external urethral orifice is situated in the vestibule of the vagina. In the male the external urethral orifice is at the tip of the glans penis. The female urethra serves exclusively as a conduit for urine. In the male, however, the urethra is a common channel for urine and seminal fluid.

The female urethra

The female urethra in the adult is approximately 4 cm in length and 6 mm in diameter. Commencing at the internal urethral orifice within the bladder neck, it passes antero-inferiorly below and behind the pubic symphysis to end at the external urethral orifice. The latter is located in the vestibule immediately anterior to the vaginal orifice and 2.5 cm postero-inferior to the clitoris. For its entire length the urethra lies immediately in front of the anterior wall of the vagina, and except for its very proximal part, which lies embedded in the anterior vaginal wall. Thus the long axis of the urethra is parallel to that of the anterior vaginal wall. Together the urethra and vagina pass successively through the pelvic floor, the external urethral sphincter and the perineal membrane. (The latter is described in the section on the male urethra.) The external urethral sphincter in the female, as in the male, is made up of slow-twitch fibres and is innervated by the perineal branch of the pudendal nerve. Multiple, small mucus-secreting glands situated in the subepithelial tissue of the proximal urethra, open directly into the urethra. In addition, there is an aggregation of small glands (termed Skene's glands) on either side of the distal part of the urethra. Each of these collections of glands opens into a para-urethral duct which in turn opens through a minute aperture alongside the external urethral orifice.

The male urethra

The male urethra is 18–20 cm long in an adult and leads from the internal urethral meatus in the bladder neck to the external urethral orifice (see Figure 2). The male urethra may be described as comprising four anatomically distinct segments (see Figure 4). Besides anatomical differences these segments also have certain important functional differences. In proximal to distal sequence the four segments are the pre-prostatic urethra, prostatic urethra, membranous urethra and spongiose urethra. The spongiose urethra, so named because it is located entirely within the corpus spongiosum, is further subdivided into three successive parts: bulbar, penile and glanular. The *bulbar* (or bulbous) urethra is the most proximal part of the spongiose urethra and lies within the bulbous part of the corpus spongiosum. The bulbar urethra is succeeded by the *penile* or pendulous urethra which lies within the penile shaft. The *glanular* urethra is the distal part of the spongiose urethra and refers to the part that lies within the glans penis. In urological nomenclature, the pre-prostatic, prostatic and membranous segments of the urethra are collectively referred to as the *posterior urethra* while the entire spongiose urethra is termed the *anterior urethra*. The division into anterior and posterior urethra is entirely descriptive and somewhat arbitrary.

In a supine subject or a subject in the lithotomy position, the pre-prostatic, prostatic and membranous segments of the urethra are seen to run almost horizontally forward. *The bulbar urethra* runs obliquely upwards and forwards from its junction with the membranous urethra. *The penile urethra* runs obliquely downwards and forwards from its junction with the bulbous urethra at the penoscrotal junction opposite the insertion of the suspensory ligament of the penis (see Figure 2). Thus when the penis is in a flaccid, non-tumescent state the urethra presents a double curve. Except during the passage of urine the urethral canal is no more than a narrow slit. *The pre-prostatic urethra* is approximately 1 cm in length and extends vertically from the internal urethral meatus at the bladder neck to the superior aspect (base) of the prostate. It possesses a stellate lumen, a feature which is readily observed during urethroscopy. The non-striated smooth muscle fibre bundles surrounding the bladder neck and pre-prostatic urethra are arranged as a distinct collar. The smooth muscle surrounding the pre-prostatic urethra, unlike the detrusor muscle, is almost totally devoid of parasympathetic cholinergic fibres – but is richly supplied with sympathetic noradrenergic fibres. Similar sympathetic nerve fibres also supply the smooth muscle of the prostatic stroma, the seminal vesicles and the ductus deferens (vas deferens), and are involved in causing muscle contraction at the time of ejaculation. Contraction of the

pre-prostatic sphincter serves to prevent retrograde flow of ejaculate through the proximal urethra into the bladder. It is important to specify that the pre-prostatic sphincter which is made up of noradrenergically-innervated smooth muscle is a feature unique to the male. It is a *genital sphincter* and functionally quite distinct from the bladder neck *urinary sphincter*. *The prostatic urethra* is the widest and most dilatable segment of the male urethra. It is 3.5–4 cm long and traverses the entire height of the prostate from the base of the prostate just below the bladder neck, to the prostatic apex. The prostatic urethra may be divided descriptively into proximal and distal segments of approximately equal length by a somewhat abrupt anterior angulation of its posterior wall at approximately the midpoint between prostatic apex and bladder neck. This angle of ventral deviation is variable but is usually about 35°. In men with nodular hyperplasia of the prostate, the angle tends to be greater. The prostatic urethra lies nearer the anterior than posterior surface of the prostate. It is widest midway along its length, and narrowest distally where it adjoins the membranous urethra. In cross section it appears crescentic in outline with the convex side facing ventrally. The characteristic crescentic shape is due to the presence on the posterior wall of a narrow median longitudinal ridge termed the urethral crest. The urethral crest is formed by an elevation of the mucous membrane and subjacent tissue. On each side of the crest lies a shallow longitudinal depression termed the prostatic sinus, the floor of which is pierced by the prostatic ducts. About half-way down the length of the urethral crest, the colliculus seminalis (also known as verumontanum) forms an elevation on which the slit-like orifice of the prostatic utricle is situated. On each side of this orifice are the openings of the right and left common ejaculatory ducts. The urethra emerges from the prostate just in front of the prostatic apex. Immediately upon leaving the prostate the urethra enters the deep perineal pouch and is termed the membranous urethra. *The membranous urethra* is a very narrow part of the urethra and is the least mobile and least dilatable segment of the urethra. It is 1.5 cm long. Stretching across the width of the, urogenital triangle of the perineum, between the right and left ischio-pubic rami, and confined to the urogenital triangle is a distinct fascial layer termed the perineal membrane. The perineal membrane serves to demarcate the two principal subdivisions of the urogenital triangle: the deep perineal pouch and superficial perineal pouch. The former lies deep to (that is to say above) the perineal membrane and contains the membranous urethra, external urethral sphincter (the voluntary, striated muscle sphincter) and, in the male, the bulbo-urethral glands (Cowper's glands). The latter lie posterolateral to the membranous urethra. (The ducts of the bulbo-urethral glands, however, penetrate the perineal membrane and open into the bulbar urethra in the superficial perineal pouch). The superficial perineal pouch lies superficial to (that is to say below) the perineal membrane. This demarcation into the superficial and deep perineal pouches is more apparent in the male subject (owing to the perineal membrane being a more readily demonstrable entity in the male). *The spongiose urethra* is approximately 15 cm in length and is enclosed, along its entire length, by the corpus spongiosum (see Figure 2). The latter which consists of erectile tissue, lies in the ventral groove between the two corpora cavernosa (see Figure 4). The corpus spongiosum is enlarged proximally to form the bulb of the penis. At its distal end the corpus spongiosum is expanded to form a broad cap called the glans penis. The spongiose urethra is the direct continuation of the membranous urethra, and as has already been stated, is subdivided descriptively into bulbar, penile and glanular parts. Just proximal to the external urethral orifice, the glanular urethra features a short dilated portion, called the navicular fossa. The prostatic and membranous segments are lined with transitional epithelium. The spongiose urethra is lined with pseudostratified columnar epithelium proximally, and with stratified squamous epithelium distally. The distal half of the spongiose urethra receives the minute ducts of multiple mucus-secreting periurethral glands (glands of Littré).

The prostate

The prostate is an encapsulated fibromuscular gland that is wholly in the pelvic cavity. It surrounds the urethral lumen and is developed only in the male. It is in the shape of an inverted pyramid and lies in contact with the gutter-shaped pelvic floor just behind the lower part of the pubic symphysis, immediately below the bladder neck (see Figures 2, 3 and 4). It is developmentally and actually a thickened part of the urethra. Its firm consistency is due to the presence of a substantial amount of smooth muscle and fibrous tissue in its stroma. Secretions of the glandular follicles of the prostate account for much of the volume of seminal fluid. Posterior to the urethra the prostate is traversed obliquely and inferomedially on either side of the midline by the corresponding ejaculatory duct. The prostate is contained within a tough fibrous capsule. Immediately outside the prostatic capsule is the peri-prostatic venous plexus (of Santorini) that covers all but the posterior aspect of the prostate (see Figure 3). Outside the venous plexus is a covering of pelvic fascia.

Lobar anatomy

The prostate has traditionally been described as consisting of five lobes: an anterior lobe (in front of the urethra), a median lobe (situated between the common ejaculatory ducts and immediately behind the proximal urethra), two lateral lobes (right and left) and an inferoposterior lobe. Enlargement of the median lobe is thought to underlie the formation of the uvula that is sometimes seen to project into the internal urethral orifice in cases of urinary obstruction. However, it is now widely acknowledged that this lobar anatomy is evident only in the neonate.

Zonal anatomy

From a clinicopathological perspective it is more useful to describe the prostate in terms of three concentric zones: a peripheral zone, a central zone and a transitional zone. Immediately deep to the capsule is the peripheral zone which is composed primarily of acinar glandular tissue. This zone accounts for 70% of the volume of the prostate in youth. It is the site of origin of the majority of prostatic cancers. Anteriorly the peripheral zone is interrupted by relatively acellular tissue that comprises the fibroelastic zone. Deep to the peripheral zone is the central zone which is composed mainly of stromal cells. Only 10% or so of prostate cancers originate in this zone. Deep to the central zone and immediately peripheral to the prostatic urethra are the bilobed transitional zones – the most frequent sites for hyperplastic nodules; 20% of prostate

cancers arise in the transitional zones. The transitional zone enlarges from approximately 5% of the gland's volume in youth to about 80–90% of the prostatic volume in senescence.

The blood supply to the prostate is principally from the prostatic branch of the inferior vesical artery. The prostatic artery gives rise to two types of branches: capsular and urethral. The venous drainage of the prostate is to the peri-prostatic venous plexus. This plexus communicates indirectly with the peri-rectal venous plexus which in turn connects with the internal vertebral venous plexus in the vertebral canal through the anterior sacral foramina. This venous pathway is the route taken by cancer cells that metastasize from the prostate to the vertebral column.

Seminal vesicle

Each seminal vesicle is an elongated oval structure, 5–7 cm long and 2 cm wide with a capacity of 3–4 ml. It does not store sperm but contributes a large amount of fluid to the ejaculate. The seminal vesicle is applied to the posterior surface of the urinary bladder, directly posterior to the trigonal region and immediately above the prostate (see Figure 3). It consists of a single, highly coiled, thin-walled tube, which when straightened is nearly 15 cm long. Its compact appearance on gross inspection is due to the fairly dense connective tissue that binds the coils together. The coils give the seminal vesicle a lobulated appearance. Each seminal vesicle is, in effect, a diverticulum from the lateral aspect of the vas deferens, the opening of the seminal vesicle lying immediately distal to the ampulla of the vas. Distal to its confluence with the seminal vesicle, the vas is referred to as the common ejaculatory duct. The latter, which is about 2 cm long, traverses the prostate obliquely in an inferomedial direction before opening into the posterior wall of the prostatic urethra immediately lateral to the utricle on the colliculus seminalis (verumontanum). The upper end of each seminal vesicle lies immediately lateral to the ipsilateral terminal ureter and just below the rectovesical fold of peritoneum which runs from the very upper part of the posterior surface of the bladder to the anterior aspect of the rectum (see Figures 2 and 3). Below the rectovesical peritoneal fold, the rectovesical fascia (fascia of Denonvilliers) is interposed between the posteriorly located rectum and the anteriorly situated genitourinary structures namely the seminal vesicles, terminal segments of the ureters and ducti deferens, prostate and base of the urinary bladder (see Figure 2). The blood supply to the seminal vesicle is mainly from the inferior vesical artery while its venous drainage is to the prostatic venous plexus. Serial measurements of the size of the seminal vesicles estimated by transrectal ultrasonography have shown that the seminal vesicles enlarge progressively from the age of 20 years, reaching a peak at about 45 years. Thereafter the seminal vesicles gradually shrink. ◆

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