general urology

9th

EDITION

d. r. smith

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Preface

This book was originally written with the medical student in mind, but as new editions appeared it became evident that urologic residents as well as urologists and physicians in other fields were finding it useful.

The thesis of the book is that although many urologic disorders produce few or no symptoms, the clues to their presence lie in careful history-taking and physical examination and, above all, a personally performed study of the fresh, stained urinary sediment and utilization of the PSP renal function test, which also permits estimation of the amount of residual urine. It has become increasingly apparent that there is a need for both voiding cystourethrograms and excretory urograms in order to demonstrate vesicoureteral reflux (the most common cause of renal infection) and other lesions, including posterior urethral valves. More sophisticated tests such as angiography, venography, sonography, radioisotopic studies, and computed tomography have come to be essential for diagnosis in many cases. Rapid advances in our understanding of the immunologic aspects of genitourinary tumors may prove helpful in diagnosis and treatment and in the assessment of the prognosis of such neoplasms.

In order to improve some of the chapters, I have turned to Dr. Emil A. Tanagho, who, in addition to his contribution to the chapter on embryology of the genitourinary tract, has rewritten the chapters on anatomy, urinary obstruction and stasis, vesicoureteral reflux, neuropathic bladder disorders, and disorders of the female urethra. The section on schistosomiasis has been revised by Professor Mohamed M. Al-Ghorab of the Faculty of Medicine, University of Alexandria, Egypt. Dr. Samuel D. Spivack has contributed an extensive discussion of the chemotherapeutic treatment of urologic malignancies. Computed tomography has become an important tool in the study of the genitourinary tract, and Dr. Melvyn T. Korobkin has prepared a well-illustrated explanation of this technic for our readers. Thanks are due also to Dr. Ernest Jawetz for his assistance in the chapter on nonspecific infections of the urinary tract.

The extensive bibliographies, which have received much favorable comment, have been brought up to date.

It is a pleasure to note that this book is currently available in a Spanish, a Japanese, and a Polish edition. Preparations are under way for translation of the book into German, Italian, and Portuguese.

Donald R. Smith, MD

Piscataway, New Jersey
August, 1978

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Table of Contents

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Anatomy of the Genitourinary Tract

Urology deals with diseases and disorders of the genitourinary tract in the male and of the urinary tract in the female. Surgical diseases of the adrenal gland are also included. These systems are illustrated in Figs 1–1 and 1–2.

ADRENALS

Gross Appearance

A. Anatomy: Each kidney is capped by an adrenal gland, and both organs are enclosed within Gerota's (perirenal) fascia. Each adrenal weighs about 5 g. The right adrenal is triangular in shape; the left is more rounded and crescentic. Each gland is composed of a cortex, chiefly influenced by the pituitary gland, and a medulla derived from chromaffin tissue.

B. Relations: Fig 1–2 shows the relation of the adrenals to other organs. The right adrenal lies between the liver and the vena cava. The left gland lies close to the aorta and is covered on its lower surface by the pancreas; superiorly and laterally, it is related to the spleen.

Histology

The adrenal cortex is composed of 3 distinct layers: the outer zona glomerulosa, the middle zona fasciculata, and the inner zona reticularis. The medulla lies centrally and is made up of polyhedral cells containing eosinophilic granular cytoplasm. These chromaffin cells are accompanied by ganglion and small round cells.

Blood Supply

A. Arterial: Each adrenal receives 3 arteries: one from the inferior phrenic artery, one from the aorta, and one from the renal artery.

B. Venous: The right adrenal blood is drained by a very short vein which empties into the vena cava; the left adrenal vein terminates in the left renal vein.

Lymphatics

The lymphatic vessels accompany the suprarenal vein and drain into the lumbar lymph nodes.

KIDNEYS

Gross Appearance

A. Anatomy: The kidneys lie along the borders of the psoas muscles and are therefore obliquely placed. The position of the liver causes the right kidney to be lower than the left (Figs 1–2 and 1–3). The adult kidney weighs about 150 g.

The kidneys are supported by the perirenal fat (which is enclosed in the perirenal fascia), the renal vascular pedicle, abdominal muscle tone, and the general bulk of the abdominal viscera. Variations in these factors permit variations in the degree of renal mobility. The average descent on inspiration or on assuming the upright position is 4–5 cm. Lack of mobility suggests abnormal fixation (eg, perinephritis), but extreme mobility is not necessarily pathologic.

On longitudinal section (Fig 1–4), the kidney is seen to be made up of an outer cortex, a central medulla, and the internal calyces and pelvis. The cortex is homogeneous in appearance. Portions of it project toward the pelvis between the papillae and fornices and are called the columns of Bertin. The medulla consists of numerous pyramids formed by the converging collecting renal tubules, which drain into the minor calyces.

B. Relations: Figs 1–2 and 1–3 show the relations of the kidneys to adjacent organs and structures. Their intimacy with intraperitoneal organs explains, in part, some of the gastrointestinal symptoms which accompany genitourinary disease.

Histology

A. Nephron: The functioning unit of the kidney is the nephron, which is composed of a tubule which has both secretory and excretory functions (Fig 1–4). The secretory portion is contained largely within the cortex and consists of a renal corpuscle and the secretory part of the renal tubule. The excretory portion of this duct lies in the medulla. The renal corpuscle is composed of the vascular glomerulus, which projects into Bowman's capsule, which, in turn, is continuous with the epithelium of the proximal convoluted tubule. The secretory portion of the renal tubule is made up of the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule.

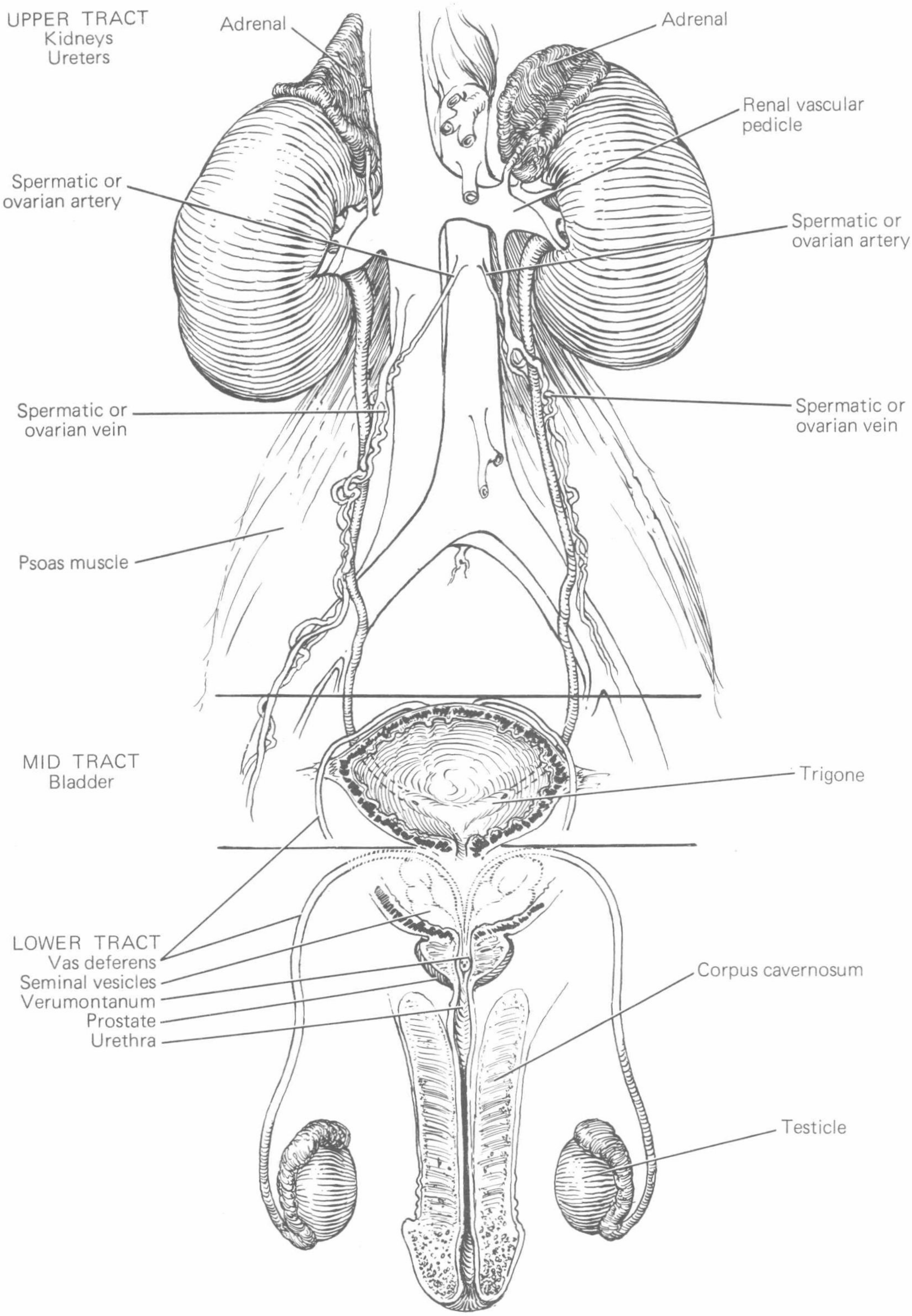

Figure 1–1. Anatomy of the male genitourinary tract. The upper and mid tracts have urologic function only. The lower tract has both genital and urinary functions.

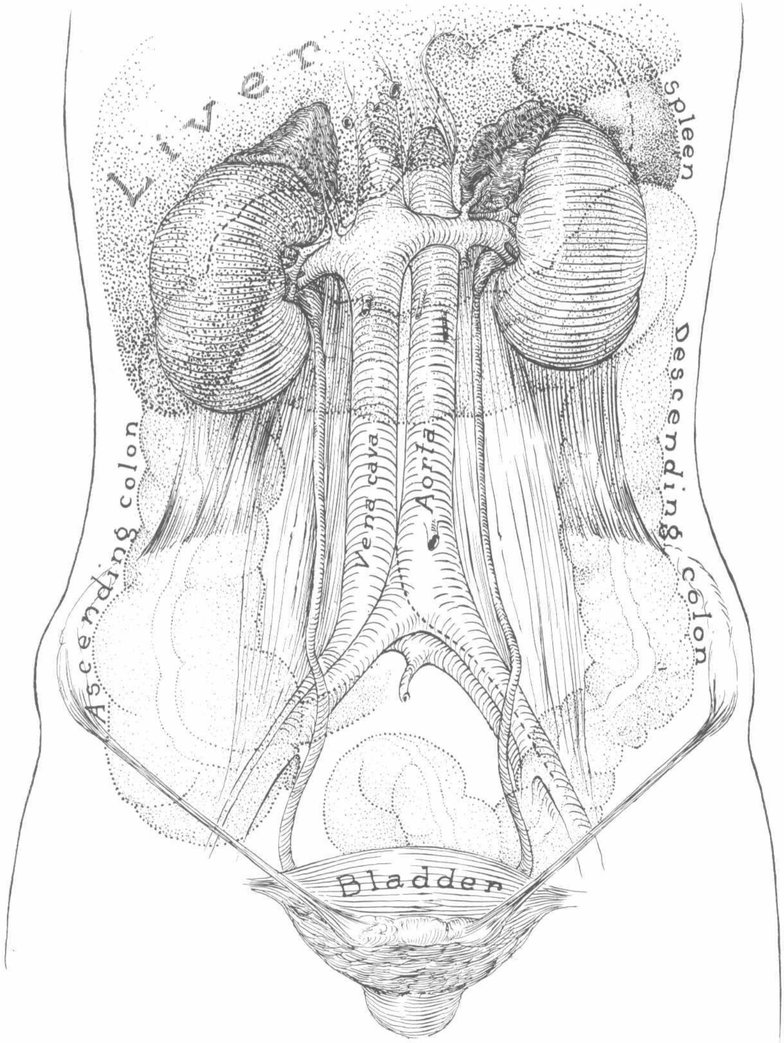

Figure 1–2. Relations of kidney, ureters, and bladder (anterior aspect).

The excretory portion of the nephron is the collecting tubule, which is continuous with the distal end of the ascending limb of the convoluted tubule. It empties its contents through the tip (papilla) of a pyramid into a minor calyx.

B. Supporting Tissue: The renal stroma is composed of loose connective tissue and contains blood vessels, capillaries, nerves, and lymphatics.

Blood Supply (Figs 1–2 and 1–4)

A. Arterial: Usually there is one renal artery, a branch of the aorta, which enters the hilum of the kidney between the pelvis, which normally lies posteriorly, and the renal vein. It may branch before it reaches the kidney, and 2 or more separate arteries may be noted. In duplication of the pelvis and ureter, it is usual for each renal segment to have its own arterial supply.

This artery further divides into the interlobular arteries, which ascend in the columns of Bertin (between the pyramids) and then arch along the base of the pyramids (arcuate arteries). From these vessels smaller (afferent) branches pass to the glomeruli. From the glomerular tuft, efferent arterioles pass to the tubules in the stroma.

B. Venous: The renal veins are paired with the arteries, but any of them will drain the entire kidney if the others are tied off.

Although the renal artery and vein are usually the sole blood vessels of the kidney, accessory renal vessels are common and may be of clinical importance if they are so placed as to compress the ureter, in which case hydronephrosis may result.

Nerve Supply

The renal nerves derived from the renal plexus

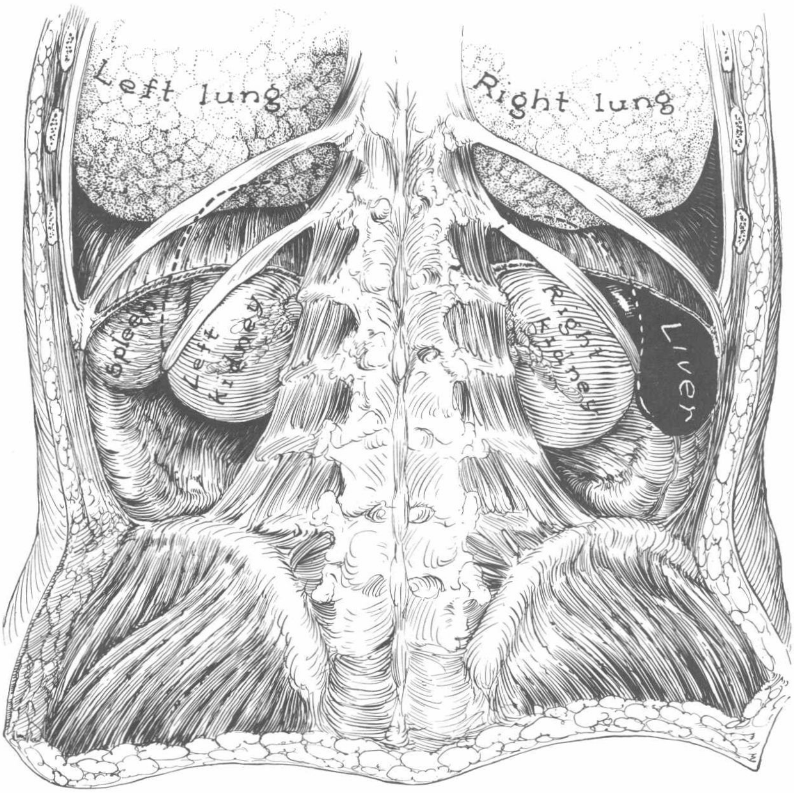

Figure 1–3. Relations of kidneys (posterior aspect).

accompany the renal vessels throughout the renal parenchyma.

Lymphatics

The lymphatics of the kidney drain into the lumbar lymph nodes (Figs 18–1 and 18–2).

CALYCES, RENAL PELVIS, & URETER

Gross Appearance

A. Anatomy:

1. **Calyces**–The tips of the minor calyces (4–12 in number) are indented by the projecting pyramids (Fig 1–4). These calyces unite to form 2 or 3 major calyces, which join the renal pelvis.

2. **Renal pelvis**–The pelvis may be entirely intrarenal or partly intrarenal and partly extrarenal. Inferomedially, it tapers to form the ureter.

3. **Ureter**–The adult ureter is about 30 cm long, varying in direct relation to the height of the individual. It follows a rather smooth S curve. Areas of constriction are found (1) at the ureteropelvic junction, (2) where the ureter crosses over the iliac vessels, and (3) where it courses through the bladder wall.

B. Relations:

1. **Calyces**–The calyces are intrarenal and are intimately related to the renal parenchyma.

2. **Renal pelvis**–If the pelvis is partly extrarenal, it lies along the lateral border of the psoas muscle and on the quadratus lumborum muscle; the renal vascular pedicle is placed just anterior to it. The left renal pelvis lies at the level of the first or second lumbar vertebra; the right pelvis is a little lower.

3. **Ureter**–As followed from above downward, the ureters lie on the psoas muscles, pass medially to the sacroiliac joints, and then swing laterally near the ischial spines before passing medially to penetrate the base of the bladder (Fig 1–2). In the female, the uterine arteries are closely related to the juxtavesical portion of the ureters. The ureters are covered by the posterior peritoneum; their lowermost portions are closely attached to it, while the juxtavesical portions are embedded in vascular retroperitoneal fat.

The vasa, as they leave the internal inguinal rings, sweep over the lateral pelvic walls anteriorly to the ureters. They lie medial to the latter before penetrating the base of the prostate to become the ejaculatory ducts.

Histology (Fig 1–4)

The walls of the calyces, pelvis, and ureters are composed of transitional cell epithelium under which lies loose connective and elastic tissue (lamina propria).

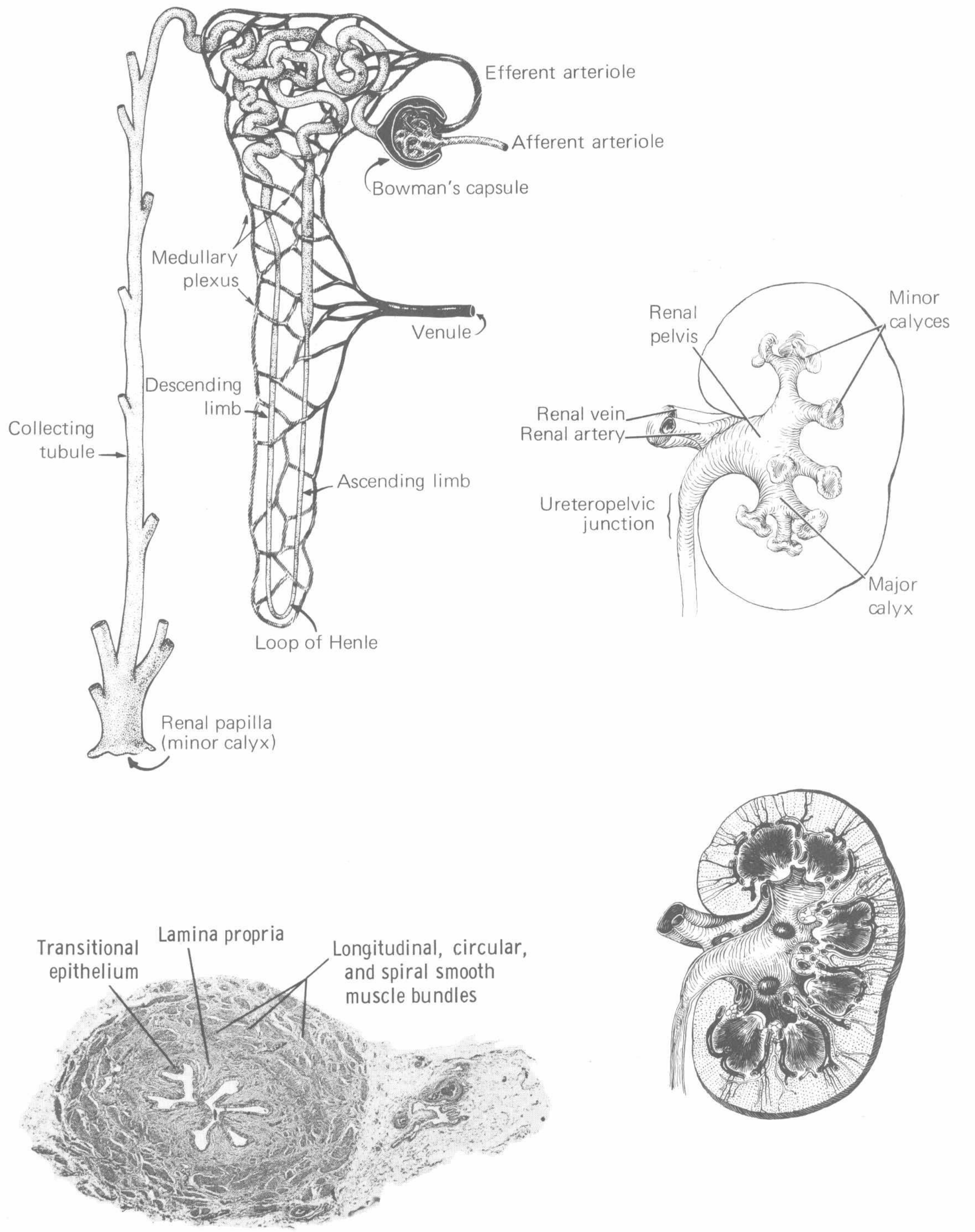

Figure 1–4. Anatomy and histology of the kidney and ureter. ***Above left:*** Diagram of the nephron and its blood supply. (Courtesy of Merck, Sharp, & Dohme: Seminar:9[3], 1947.) ***Above right:*** Renal calyces, pelvis, and ureter (posterior aspect). ***Below left:*** Histology of the ureter. The smooth muscle bundles are arranged in both a spiral and longitudinal manner. ***Below right:*** Longitudinal section of kidney showing calyces, pelvis, ureter, and renal blood supply (posterior aspect).

External to these are a mixture of spiral and longitudinal smooth muscle fibers. They are not arranged in definite layers. The outermost adventitial coat is composed of fibrous connective tissue.

Blood Supply

A. Arterial: The renal calyces, pelvis, and upper ureters derive their blood supply from the renal arteries; the mid ureter is fed by the internal spermatic (or ovarian) arteries. The lowermost portion of the ureter is served by branches from the common iliac, hypogastric, and vesical arteries.

B. Venous: The veins of the renal calyces, pelvis, and ureters are paired with the arteries.

Lymphatics

The lymphatics of the upper portions of the ureters as well as those from the pelvis and calyces enter the lumbar lymph nodes. The lymphatics of the mid ureter pass to the hypogastric and common iliac lymph nodes; the lower ureteral lymphatics empty into the vesical and hypogastric lymph nodes (Figs 18–1 and 18–2).

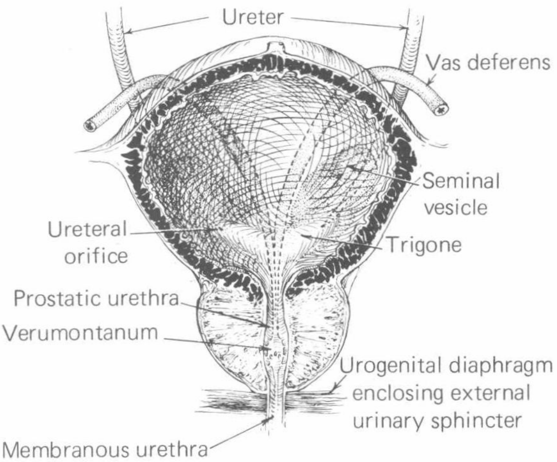

Figure 1–5. Anatomy and relations of the ureters, bladder, prostate, seminal vesicles, and vasa deferentia (anterior view).

BLADDER

Gross Appearance

The bladder is a hollow muscular organ which serves as a reservoir for urine. In women, its posterior wall and dome are invaginated by the uterus. The adult bladder has a capacity of 350–450 ml.

A. Anatomy: When empty, the adult bladder lies behind the pubic symphysis and is largely a pelvic organ. In infants and children, it is situated higher. When it is full, it rises well above the symphysis and can readily be palpated or percussed. When overdistended, as in acute or chronic urinary retention, it may cause the lower abdomen to bulge visibly.

Extending from the dome of the bladder to the umbilicus is a fibrous cord, the medial umbilical ligament, which represents the obliterated urachus. The ureters enter the bladder posteroinferiorly in an oblique manner and at these points are placed about 2.5 cm apart (Fig 1–5). The orifices are situated at the extremities of the crescent-shaped interureteric ridge which forms the proximal border of the trigone. The trigone occupies the area between the ridge and the bladder neck.

The internal sphincter, or bladder neck, is not a true circular sphincter but a thickening formed by interlaced and converging muscle fibers of the detrusor as they pass distally to become the smooth musculature of the urethra.

B. Relations: In the male, the bladder is related posteriorly to the seminal vesicles, vasa deferentia, ureters, and rectum (Figs 1–7 and 1–8). In the female, the uterus and vagina are interposed between the bladder and rectum (Fig 1–9). The dome and posterior surfaces are covered by peritoneum; hence, in this area the bladder is closely related to the small intestine and sigmoid colon. In both male and female, the bladder is related to the posterior surface of the pubic symphysis, and, when distended, it is in contact with the lower abdominal wall.

Histology (Fig 1–6)

The mucosa of the bladder is composed of transitional epithelium. Beneath it is a well-developed submucosal layer formed largely of connective and elastic tissues. External to the submucosa is the detrusor muscle, made up of a mixture of smooth muscle fibers which are arranged at random in a longitudinal, circular, and spiral manner.

Blood Supply

A. Arterial: The arterial supply to the bladder comes from the superior, middle, and inferior vesical arteries, which arise from the anterior trunk of the hypogastric artery. Smaller branches from the obturator and inferior gluteal arteries also reach this organ. In the female, the uterine and vaginal arteries also send branches to the bladder.

B. Venous: Surrounding the bladder is a rich plexus of veins which ultimately empties into the hypogastric veins.

Lymphatics

The lymphatics of the bladder drain into the vesical, external iliac, hypogastric, and common iliac lymph nodes (Figs 18–1 and 18–2).

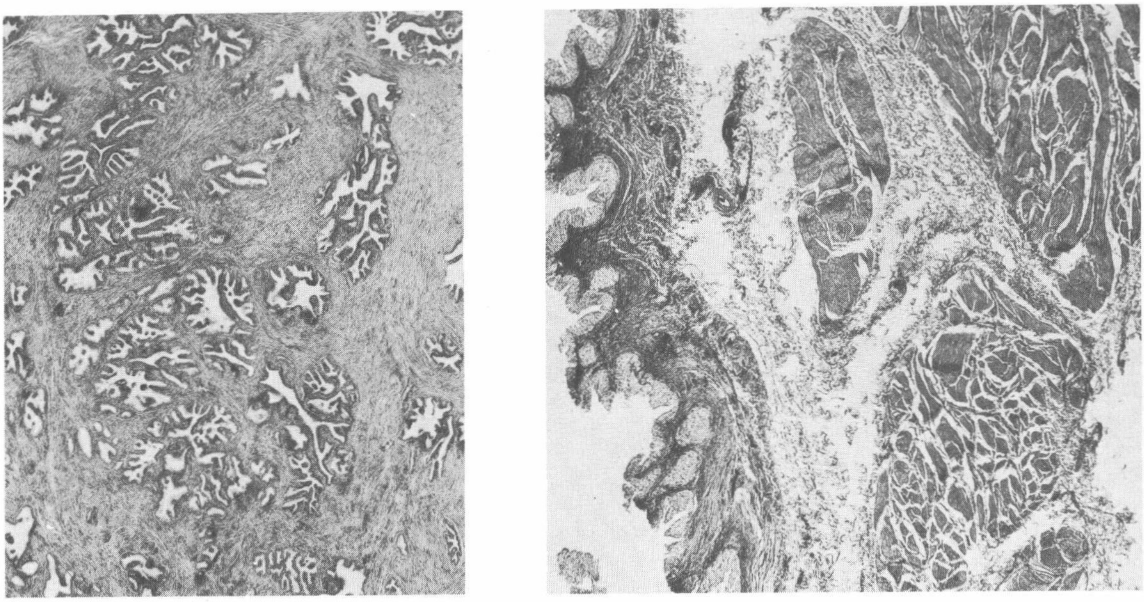

Figure 1–6. ***Left:*** Histology of the prostate. Epithelial glands embedded in a mixture of connective and elastic tissue and smooth muscle. ***Right:*** Histology of the bladder. The mucosa is transitional cell in type and lies upon a well-developed submucosal layer of connective tissue. The detrusor muscle is composed of interlacing longitudinal, circular, and spiral smooth muscle bundles.

PROSTATE GLAND

Gross Appearance

A. Anatomy: The prostate is a fibromuscular and glandular organ lying just inferior to the bladder (Figs 1–5 and 1–7). The normal prostate weighs about 20 g and contains the posterior urethra, which is about 2.5 cm in length. It is supported anteriorly by the puboprostatic ligaments and inferiorly by the urogenital diaphragm (Fig 1–5). The prostate is perforated posteriorly by the ejaculatory ducts, which pass obliquely to empty through the verumontanum on the floor of the prostatic urethra just proximal to the striated external urinary sphincter.

According to the classification of Lowsley, the prostate consists of 5 lobes: anterior, posterior, median, right lateral, and left lateral. The segment of urethra that traverses the prostate gland is the prostatic urethra. It is lined by an inner longitudinal layer of muscle (continuous with a similar layer of the vesical wall). Incorporated within the prostate gland is an abundant amount of smooth musculature derived primarily from the external longitudinal bladder musculature. This musculature represents the true smooth involuntary sphincter of the posterior urethra in the male.

Prostatic adenoma develops from the periurethral glands at the site of the median or lateral lobes. The posterior lobe, however, is prone to cancerous degeneration.

B. Relations: The prostate gland lies behind the pubic symphysis. Closely applied to its posterosuperior surface are the vasa deferentia and seminal vesicles (Fig 1–7). Posteriorly, it is separated from the rectum by the 2 layers of Denonvilliers' fascia, serosal rudiments of the pouch of Douglas which once extended to the urogenital diaphragm (Fig 1–8).

Histology (Fig 1–6)

The prostate consists of a thin fibrous capsule under which are circularly oriented smooth muscle fibers and collagenous tissue that surrounds the urethra (involuntary sphincter). Deep to this layer lies the prostatic stroma, composed of connective and elastic tissues and smooth muscle fibers in which are embedded the epithelial glands. These glands drain into the major excretory ducts (about 25 in number) which open chiefly on the floor of the urethra between the verumontanum and the vesical neck. Just beneath the transitional epithelium of the prostatic urethra lie the periurethral glands.

Blood Supply

A. Arterial: The arterial supply to the prostate is derived from the inferior vesical, internal pudendal, and middle hemorrhoidal arteries.

B. Venous: The veins from the prostate drain into the periprostatic plexus, which has connections with the deep dorsal vein of the penis and the hypogastric veins.

Nerve Supply

The prostate gland receives a rich nerve supply from the sympathetic and parasympathetic nerve plexuses.

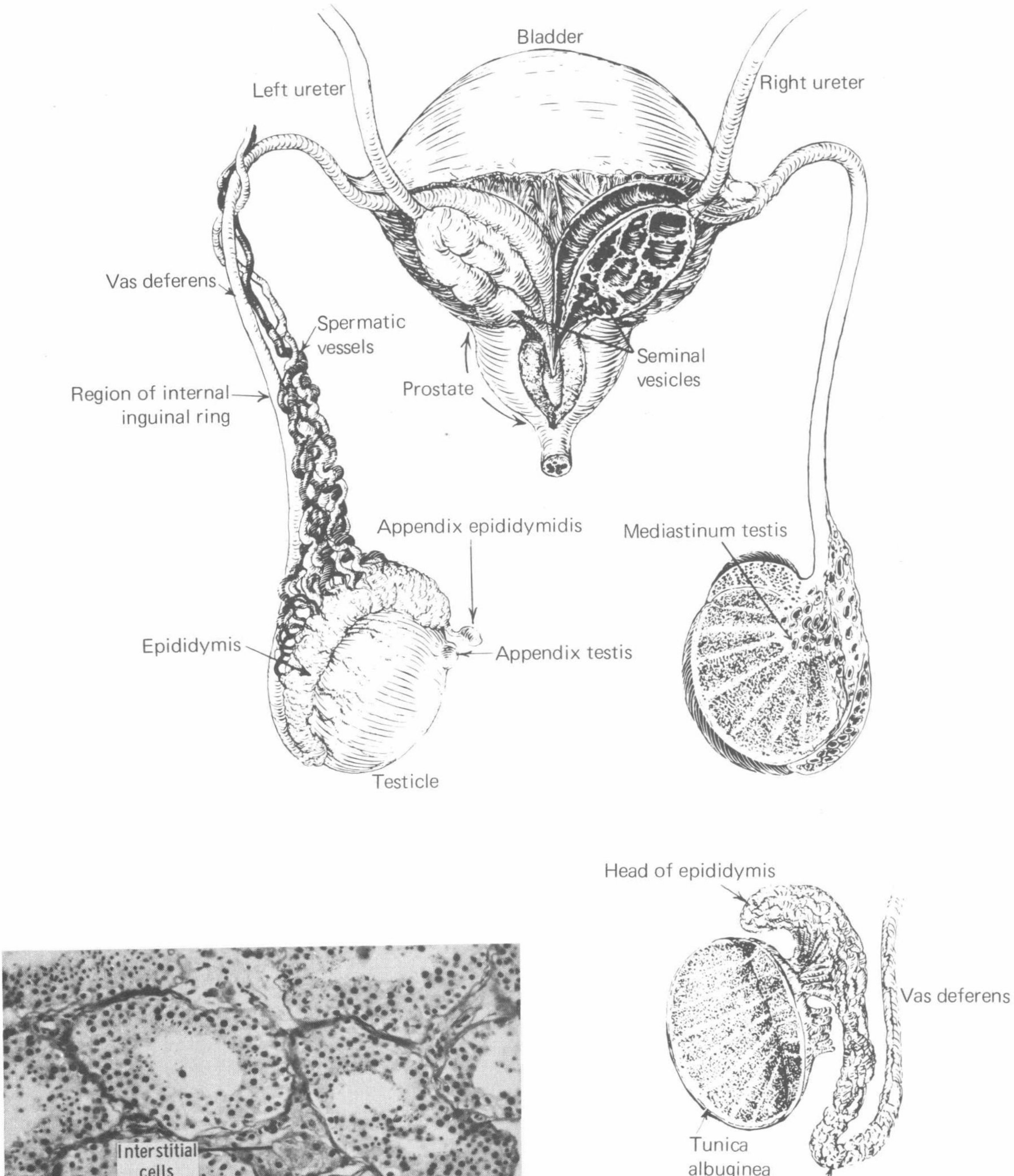

Figure 1–7. ***Above:*** Gross anatomy and relations of ureters, bladder, prostate, seminal vesicles, vasa deferentia, testes, and epididymides. ***Below left:*** Histology of the testis. Seminiferous tubules lined by supporting basement membrane for the Sertoli and spermatogenic cells. The latter are in various stages of development. ***Below right:*** Cross section of testis showing fibrous septa dividing organ into lobules.

Lymphatics

The lymphatics from the prostate drain into the hypogastric, sacral, vesical, and external iliac lymph nodes (Figs 18–1 and 18–2).

SEMINAL VESICLES

Gross Appearance

The seminal vesicles lie just cephalad to the prostate under the base of the bladder (Figs 1–5 and 1–7). They are about 6 cm long and quite soft. Each vesicle joins its corresponding vas deferens to form the ejaculatory duct. The ureters lie medial to each, and the rectum is contiguous with their posterior surfaces.

Histology

The mucous membrane is pseudostratified. The submucosa consists of dense connective tissue covered by a thin layer of muscle which in turn is encapsulated by connective tissue.

Blood Supply

The blood supply is similar to that of the prostate gland.

Nerve Supply

The nerve supply is mainly from the sympathetic nerve plexus.

Lymphatics

The lymphatics of the seminal vesicles are those that serve the prostate (Figs 18–1 and 18–2).

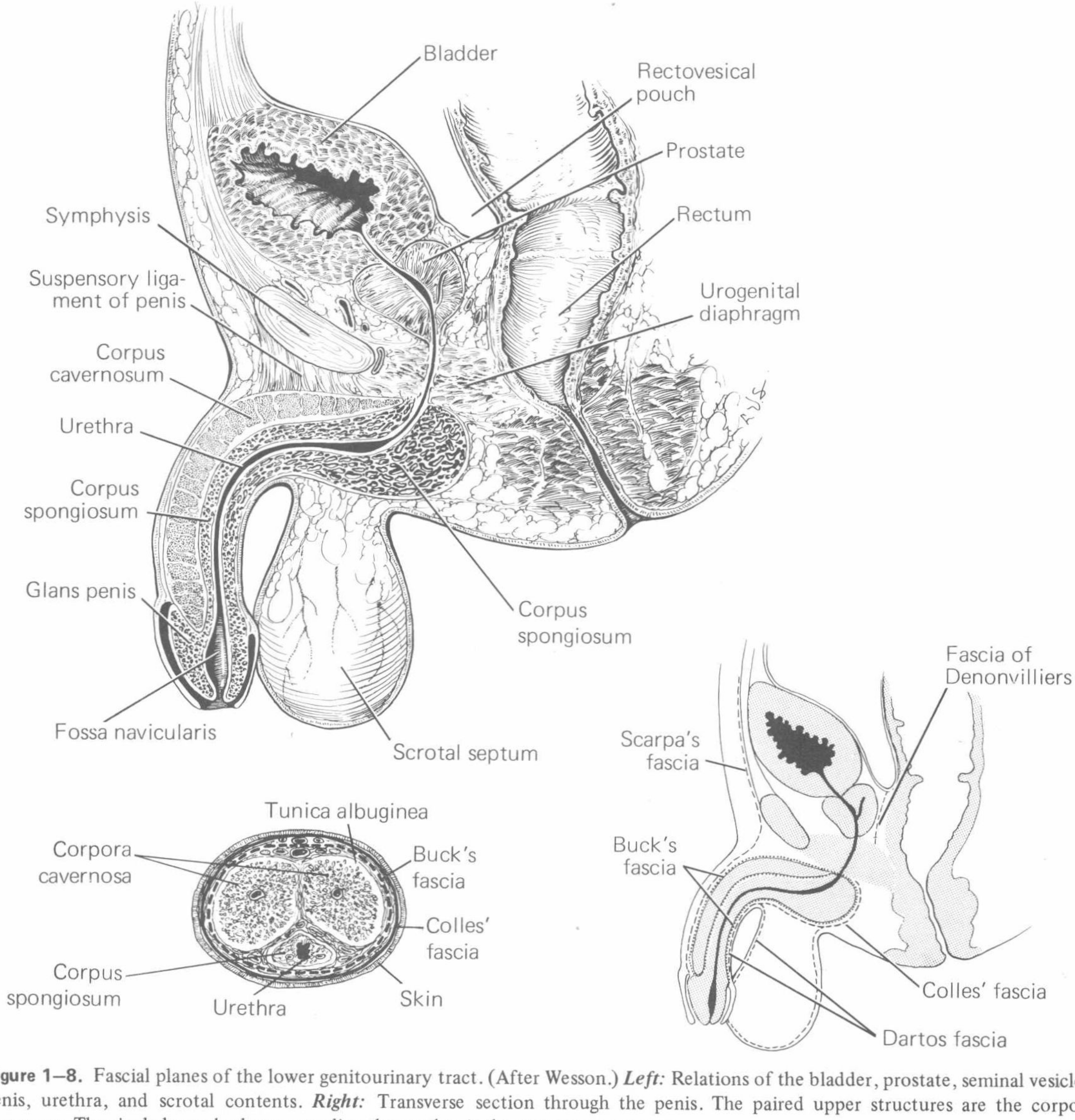

Figure 1–8. Fascial planes of the lower genitourinary tract. (After Wesson.) ***Left:*** Relations of the bladder, prostate, seminal vesicles, penis, urethra, and scrotal contents. ***Right:*** Transverse section through the penis. The paired upper structures are the corpora cavernosa. The single lower body surrounding the urethra is the corpus spongiosum.

SPERMATIC CORD

Gross Appearance

The 2 spermatic cords extend from the internal inguinal rings through the inguinal canals to the testicles (Fig 1–7). Each cord contains the vas deferens, the internal and external spermatic arteries, the artery of the vas, the venous pampiniform plexus (which forms the spermatic vein superiorly), lymph vessels, and nerves. All of the above are enclosed in investing layers of thin fascia. A few fibers of the cremaster muscle insert on the cords in the inguinal canal.

Histology

The fascia covering the cord is formed of loose connective tissue which supports arteries, veins, and lymphatics. The vas deferens is a small, thick-walled tube consisting of an internal mucosa and submucosa surrounded by 3 well-defined layers of smooth muscle encased in a covering of fibrous tissue. Above the testes, this tube is straight. Its proximal 4 cm tend to be convoluted.

Blood Supply

A. Arterial: The external spermatic artery, a branch of the inferior epigastric, supplies the fascial coverings of the cord. The internal spermatic artery passes through the cord on its way to the testis. The deferential artery is close to the vas.

B. Venous: The veins from the testis and the coverings of the spermatic cord form the pampiniform plexus, which, at the internal inguinal ring, unites to form the spermatic vein.

Lymphatics

The lymphatics from the spermatic cord empty into the external iliac lymph nodes (Figs 18–1 and 18–2).

EPIDIDYMIS

Gross Appearance

A. Anatomy: The upper portion of the epididymis (globus major) is connected to the testis by numerous efferent ducts from the testis (Fig 1–7). The epididymis consists of a markedly coiled duct which, at its lower pole (globus minor), is continuous with the vas deferens. An appendix of the epididymis is often seen on its upper pole; this is a cystic body that in some cases is pedunculated but in others is sessile.

B. Relations: The epididymis lies posterolateral to the testis and is nearest to the testis at its upper pole. Its lower pole is connected to the testis by fibrous tissue. The vas lies posteromedial to the epididymis.

Histology

The epididymis is covered by serosa. The ductus epididymidis is lined by pseudostratified columnar epithelium throughout its length.

Blood Supply

A. Arterial: The arterial supply to the epididymis comes from the internal spermatic artery and the artery of the vas (deferential artery).

B. Venous: The venous blood drains into the pampiniform plexus, which becomes the spermatic vein.

Lymphatics

The lymphatics drain into the external iliac and hypogastric lymph nodes (Figs 18–1 and 18–2).

TESTIS

Gross Appearance

A. Anatomy: The average testicle measures about 4 × 3 × 2.5 cm (Fig 1–7). It has a dense fascial covering called the tunica albuginea testis, which, posteriorly, is invaginated somewhat into the body of the testis to form the mediastinum testis. This fibrous mediastinum sends fibrous septa into the testis, thus separating it into about 250 lobules.

The testis is covered anteriorly and laterally by the visceral layer of the serous tunica vaginalis, which is continuous with the parietal layer that separates the testis from the scrotal wall.

At the upper pole of the testis is the appendix testis, a small pedunculated or sessile body which is similar in appearance to the appendix of the epididymis.

B. Relations: The testis is closely attached posterolaterally to the epididymis, particularly at its upper and lower poles.

Histology (Fig 1–7)

Each lobule contains 1–4 markedly convoluted seminiferous tubules, each of which is about 60 cm long. These ducts converge at the mediastinum testis, where they connect with the efferent ducts which drain into the epididymis.

The seminiferous tubule has a basement membrane containing connective and elastic tissue. This supports the seminiferous cells, which are of 2 types: (1) Sertoli (supporting) cells and (2) spermatogenic cells. The stroma between the seminiferous tubules contains connective tissue in which the interstitial Leydig cells are located.

Blood Supply

The blood supply to the testes is closely associated with that to the kidneys because of the common embryologic origin of the 2 organs.

A. Arterial: The arteries to the testes (internal spermatics) arise from the aorta just below the renal arteries and course through the spermatic cords to the