19th edition

Smith & Tanagho's GENERAL UROLOGY

Jack W. McAninch • Tom F. Lue

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Smith & Tanagho's General Urology

NINETEENTH EDITION

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Preface

Smith & Tanagho's General Urology, nineteenth edition, provides the updated information for the understanding, diagnosis, and treatment of urological diseases in a concise and well-organized format. The book is up-to-date, to the point, and readable.

Medical students will find this book useful because of its concise, easy-to-follow format, and its breadth of information on common urological diseases. Residents, as well as practicing physicians in urology, family practice, or general medicine, will find it an efficient and current reference, particularly because of its emphasis on diagnosis and treatment.

This nineteenth edition has been thoroughly updated with clinical information and current references. The reader will find that this edition is written in an uncomplicated, straightforward manner that provides relevant clinical information and guidelines for diagnosis and management of urologic conditions. Chapters on immunotherapy in urologic malignancies, radiotherapy of urologic tumors, urinary incontinence, and vascular interventional radiology have all undergone extensive revision. For this current edition, we have added two chapters on the timely topic of gender dysphoria and introduction to clinical research design.

Many illustrations and figures have been modernized and improved with added color. The classic fine anatomic drawings demonstrate well the important clinical findings.

This book has been one of the leading sources of information for students, trainees, and urologists around the world. In addition to English, this book has been published in many other foreign languages, like Chinese, French, Greek, Italian, Japanese, Korean, Portuguese, Russian, Spanish, and Turkish.

We greatly appreciate the patience and efforts of our McGraw-Hill staff, the expertise of our contributors, and the support of our readers.

Jack W. McAninch, MD, FACS, FRCS(E) (Hon)
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San Francisco, California, January 2020

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1 Anatomy of the Genitourinary Tract

Emil A. Tanagho, MD; & Tom F. Lue, MD, ScD (Hon), FACS

Urology deals with diseases and disorders of the adrenal gland, the male genitourinary tract, and the female urinary tract. These systems are illustrated in Figures 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 gland weighs 4–5 g. The right adrenal is triangular in shape; the left is more rounded and crescentic. The average dimensions are 3 cm width, 5 cm length, and 1 cm thickness. Each gland is composed of a cortex, chiefly influenced by the pituitary gland, and a medulla derived from chromaffin tissue (Avisse et al, 2000; O'Donoghue et al, 2010).

B. Relations

Figure 1–2 shows the relationships between the adrenals and other organs. The right adrenal lies between the liver and the vena cava. The left adrenal lies close to the aorta and is covered on its lower surface by the pancreas. The spleen lies superior and lateral to it.

Histology

The adrenal cortex, which makes up 85% of the mass, is composed of three 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 with hormone-containing granular cytoplasm. These chromaffin cells are accompanied by a small number of sympathetic ganglion cells.

Blood Supply

A. Arterial

Each adrenal gland receives three arteries: one from the inferior phrenic artery, one from the aorta, and one from the renal artery.

B. Venous

Blood from the right adrenal gland is drained by a very short vein 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.

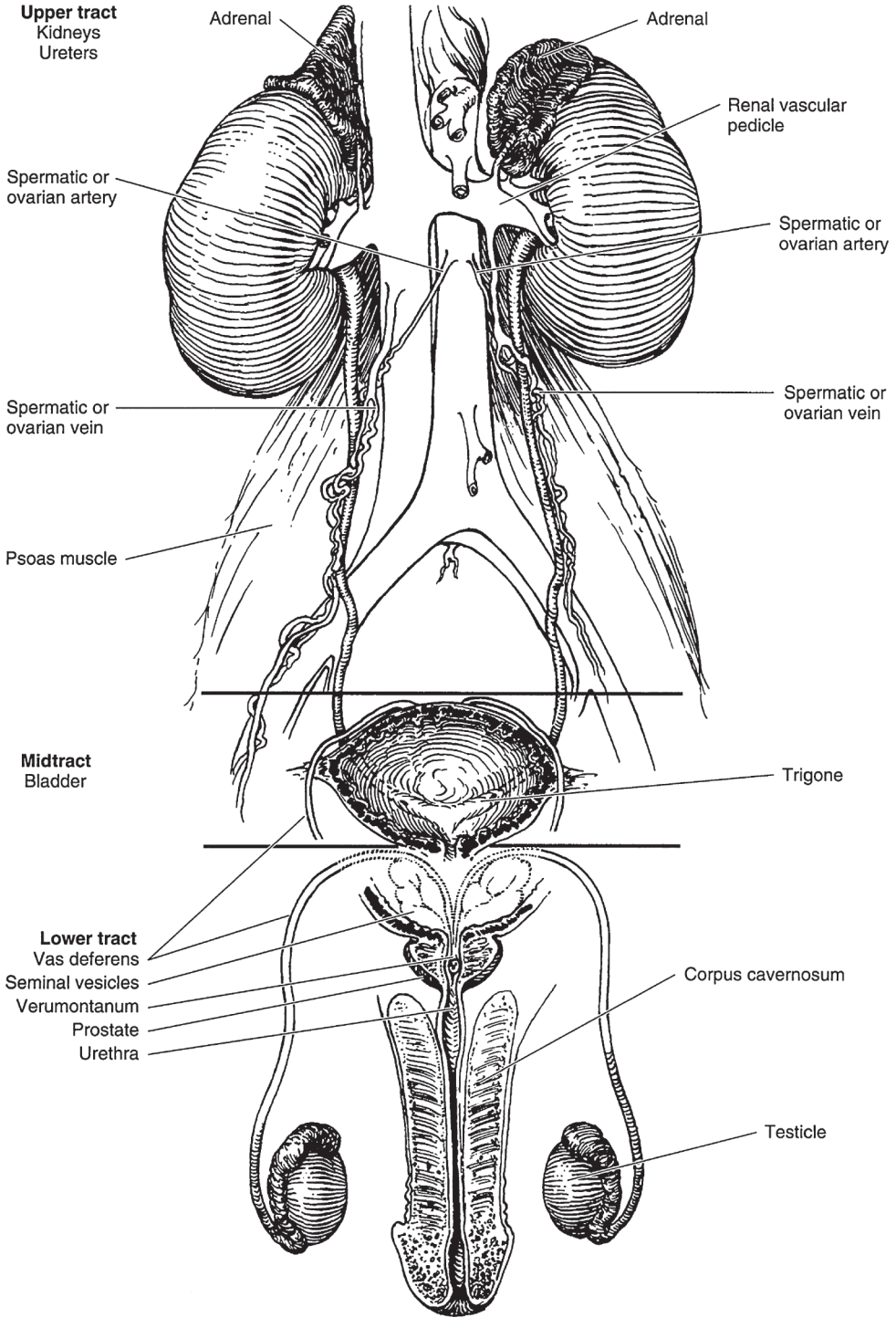
KIDNEYS

Gross Appearance

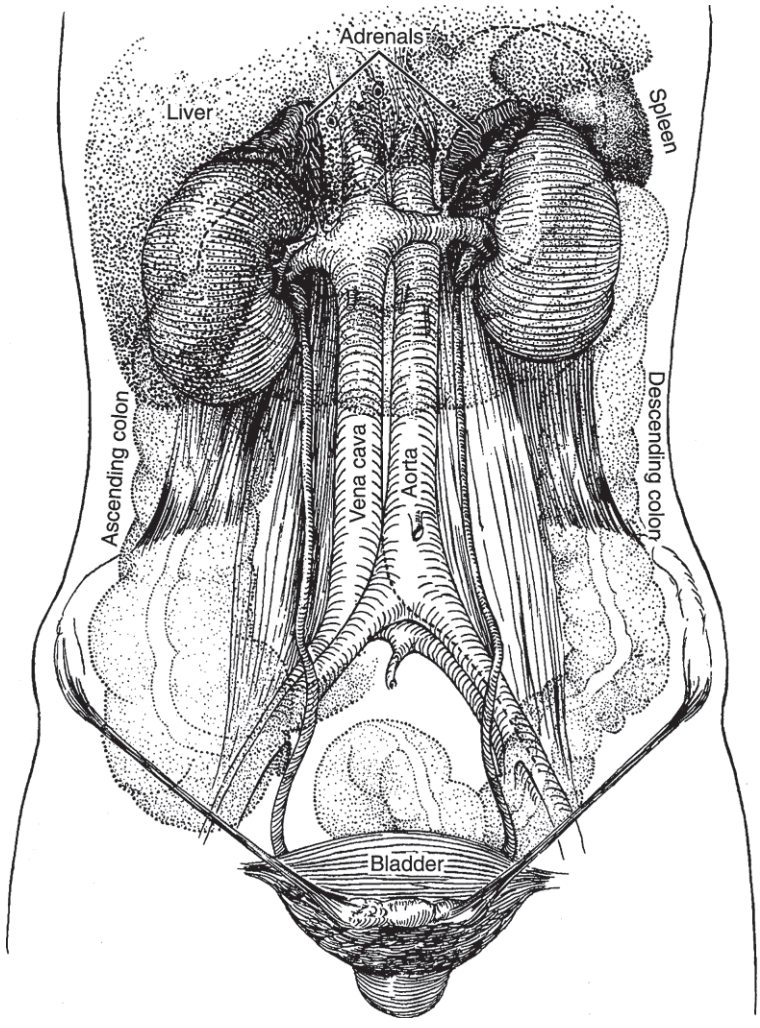
A. Anatomy

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 (Figures 1–2 and 1–3). The adult kidney weighs between 125 and 170 g in men and 115 and 155 g in women. It is about 10–12 cm long, 5–7 cm wide, and 3–5 cm thick.

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 (Rusinek et al, 2004). 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.



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



▲ **Figure 1–2.** Relations between the kidneys, ureters, and bladder (anterior aspect).

On longitudinal section (Figure 1–4), the kidney is seen to be made up of an outer cortex, a central medulla, and the internal calices 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 calices at the tip of the papillae.

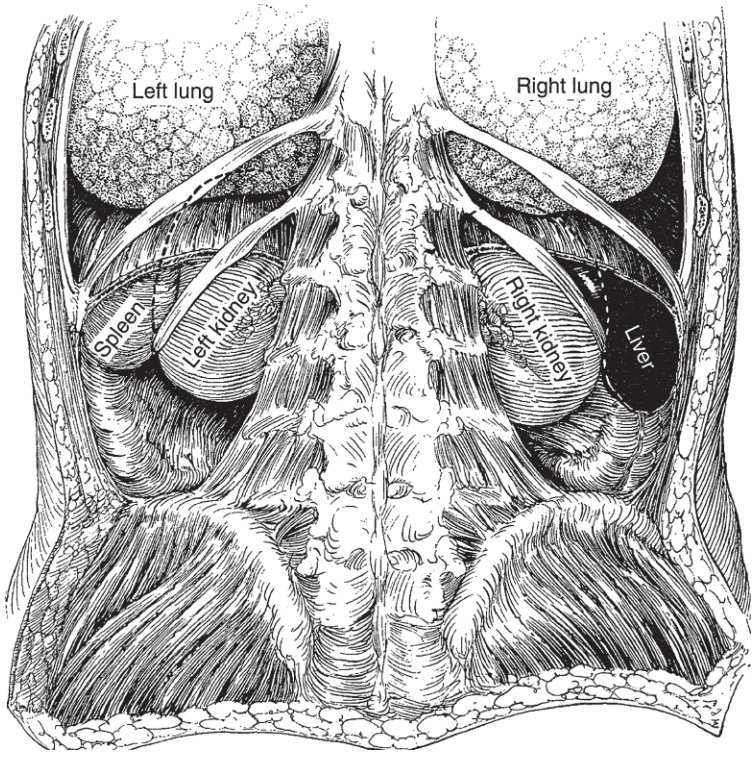
B. Relations

Figures 1–2 and 1–3 show the relationships between the kidneys and adjacent organs and structures. Their intimacy with intraperitoneal organs and the autonomic innervation that they share with these organs explain, in part, some of the gastrointestinal symptoms that accompany kidney diseases (Glassberg, 2002).

Histology

A. Nephron

The functioning unit of the kidney is the nephron, which is composed of a tubule that has both secretory and excretory functions (Figure 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



▲ **Figure 1–3.** Relations between the kidneys (posterior aspect). The dashed lines represent the outline of the kidneys, where they are obscured by overlying structures.

tubule is made up of the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule.

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 (Figures 1–2, 1–4, and 1–5)

A. Arterial

Usually there is one renal artery, a branch of the aorta that 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 two or more separate arteries may be noted (Budhiraja et al, 2010). In duplication of the pelvis and ureter, it is common for each renal segment to have its own arterial supply.

The renal artery divides into anterior and posterior branches. The posterior branch supplies the midsegment of the posterior surface. The anterior branch supplies both upper and lower poles as well as the entire anterior surface. The renal arteries are all end arteries.

The renal artery branches further divide into interlobar arteries, which travel in the columns of Bertin (between the pyramids) and then arch along the base of the pyramids (arcuate arteries). These arteries then divide as interlobular arteries. From these vessels, smaller (afferent) branches pass to the glomeruli. From the glomerular tuft, efferent arterioles pass to the tubules in the stroma.

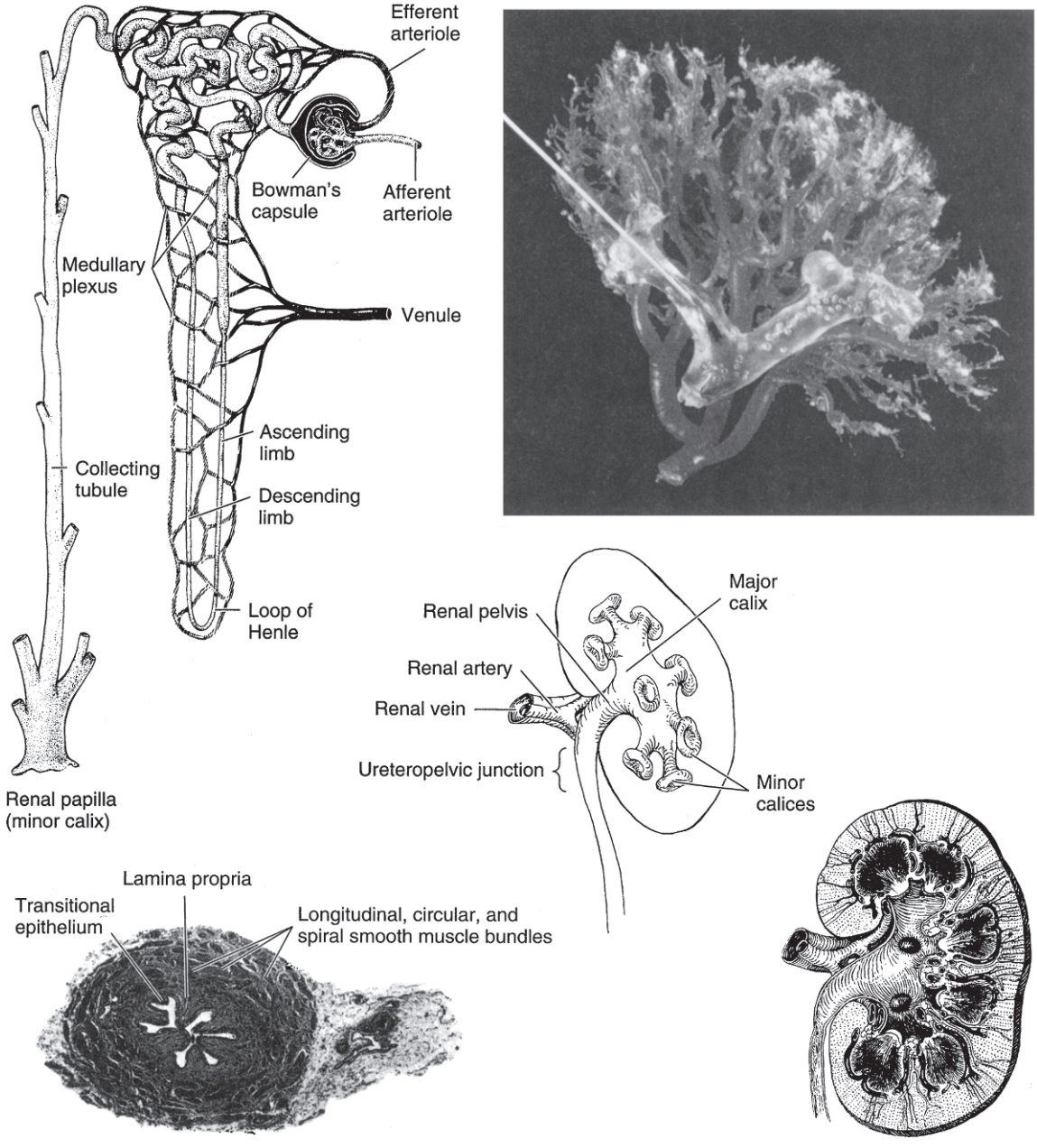
B. Venous

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

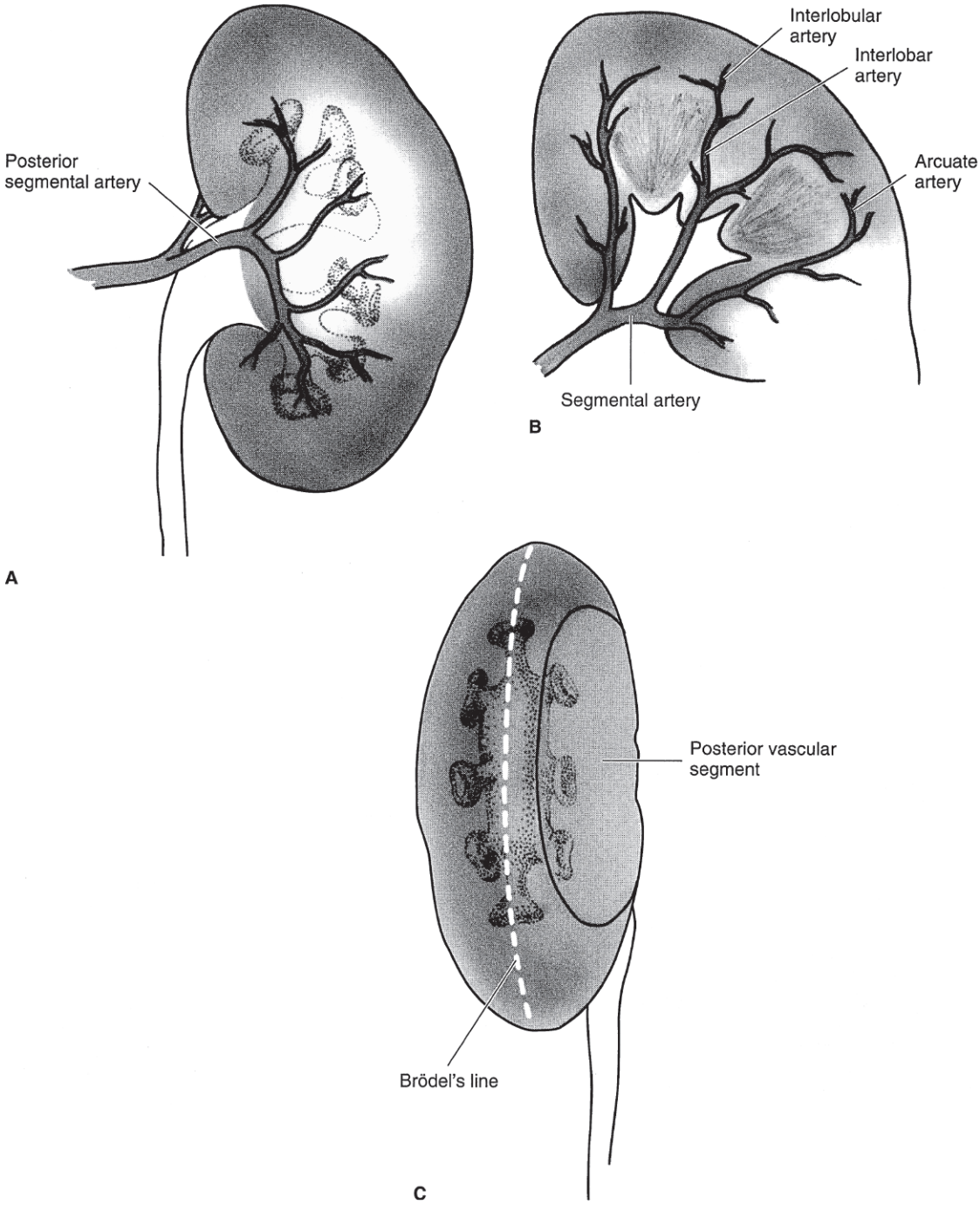
Although the renal artery and vein are usually the sole blood vessels of the kidney, accessory renal vessels are common and may be of clinical importance if they are so placed so as to compress the ureter, in which case hydronephrosis may result.

Nerve Supply

The renal nerves derived from the renal plexus accompany the renal vessels throughout the renal parenchyma.



▲ **Figure 1–4.** Anatomy and histology of the kidney and ureter. ***Upper left:*** Diagram of the nephron and its blood supply. (Courtesy of Merck, Sharp, Dohme: Seminar. 1947; 9[3].) ***Upper right:*** Cast of the pelvic caliceal system and the arterial supply of the kidney. ***Middle:*** Renal calices, pelvis, and ureter (posterior aspect). ***Lower left:*** Histology of the ureter. The smooth-muscle bundles are arranged in both spirally and longitudinally. ***Lower right:*** Longitudinal section of kidney showing calices, pelvis, ureter, and renal blood supply (posterior aspect).



▲ **Figure 1–5.** *(**A**)* The posterior branch of the renal artery and its distribution to the central segment of the posterior surface of the kidney. *(**B**)* Branches of the anterior division of the renal artery supplying the entire anterior surface of the kidney as well as the upper and lower poles at both surfaces. The segmental branches lead to interlobar, arcuate, and interlobular arteries. *(**C**)* The lateral convex margin of the kidney. Brödel's line, which is 1 cm from the convex margin, is the bloodless plane demarcated by the distribution of the posterior branch of the renal artery.

Lymphatics

The lymphatics of the kidney drain into the lumbar lymph nodes.

CALICES, RENAL PELVIS, AND URETER

Gross Appearance

A. Anatomy

1. Calices—The tips of the minor calices (8–12 in number) are indented by the projecting pyramids (Figure 1–4). These calices unite to form two or three major calices that join to form the renal pelvis (Sozen et al, 2008).

2. Renal pelvis—The pelvis may be entirely intrarenal or partly intrarenal and partly extrarenal. Inferomedially, it tapers to join 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 that stones are often impacted are (a) at the ureteropelvic junction, (b) where the ureter crosses over the iliac vessels, and (c) where it courses through the bladder wall.

B. Relations

1. Calices—The calices are intrarenal and are intimately related to the renal parenchyma.

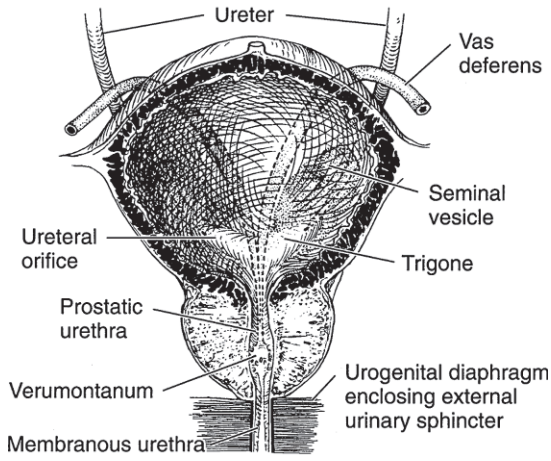
2. Renal pelvis—If the pelvis is partly extrarenal, it lies along the lateral border of the psoas muscle and on the quadratus lumborum muscle; the renal vascular pedicle is just anterior to it. The left renal pelvis lies at the level of the first or second lumbar vertebra; the right pelvis is a little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

3. Ureter—On their course 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 enter the base of the bladder (Figure 1–2). In females, 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 (Koff, 2008).

The vasa deferentia, as they leave the internal inguinal rings, sweep over the lateral pelvic walls anterior to the ureters (Figure 1–6). They lie medial to the latter before joining the seminal vesicle and penetrating the base of the prostate to become the ejaculatory ducts.

Histology (Figure 1–4)

The walls of the calices, pelvis, and ureters are composed of transitional cell epithelium under which lies loose connective tissue (lamina propria). External to these are a mixture of helical and longitudinal smooth-muscle fibers. They are not arranged in discrete layers. The outermost adventitial coat is composed of fibrous connective tissue.



▲ **Figure 1–6.** Anatomy and relations between the ureters, bladder, prostate, seminal vesicles, and vasa deferentia (anterior view).

Blood Supply

A. Arterial

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

B. Venous

The veins of the renal calices, 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 calices enter the lumbar lymph nodes. The lymphatics of the midureter pass to the internal iliac (hypogastric) and common iliac lymph nodes; the lower ureteral lymphatics empty into the vesical and hypogastric lymph nodes.

BLADDER

Gross Appearance

The bladder is a hollow muscular organ that serves as a reservoir for urine. In women, its posterior wall and dome are invaginated by the uterus. The adult bladder normally has

a capacity of 400–500 mL. The wall of the bladder is about 3–5 mm in thickness; it is thinner when it is distended.

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 (Berrocal et al, 2002). 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 median umbilical ligament, which represents the obliterated urachus. The ureters enter the bladder posteroinferiorly in an oblique manner and at these points are about 5 cm apart (Figure 1–6). The orifices, situated at the extremities of the crescent-shaped interureteric ridge that forms the proximal border of the trigone, are about 2.5 cm apart. 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 muscle component of the urethra.

B. Relations

In males, the bladder is related posteriorly to the seminal vesicles, vasa deferentia, ureters, and rectum (Figures 1–7 and 1–8). In females, the uterus and vagina are interposed between the bladder and rectum (Figure 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 males and females, 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 (Figure 1–10)

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. The mucosa may be considered as a single functional unit that consists of the epithelial layer, basement membrane, and lamina propria. Physical or chemical stress on the bladder elicits releases of multiple factors that modulate afferent and efferent nerve activities (Fry and Vahabi, 2016). External to the submucosa is the detrusor muscle that is made up of a mixture of smooth-muscle fibers arranged at random in a longitudinal, circular, and spiral manner without any layer formation or specific orientation except for proximity to the internal meatus, where the detrusor muscle assumes three definite layers: inner longitudinal, middle circular, and outer longitudinal (John et al, 2001).

Blood Supply

A. Arterial

The bladder is supplied by the superior, middle, and inferior vesical arteries, which arise from the anterior trunk of the internal iliac (hypogastric) artery, and by smaller branches from the obturator and inferior gluteal arteries. In females, the uterine and vaginal arteries also send branches to the bladder.

B. Venous

Surrounding the bladder is a rich plexus of veins that ultimately empties into the internal iliac (hypogastric) veins.

Nerve Supply

The bladder receives innervation from sympathetic and parasympathetic nervous systems. The sensory afferent of the bladder originates from both subepithelial nerve endings and nerve fibers between detrusor muscle bundles (Andersson, 2010; Birder et al, 2010; McCloskey, 2010).

Lymphatics

The lymphatics of the bladder drain into the vesical, external iliac, internal iliac (hypogastric), and common iliac lymph nodes.

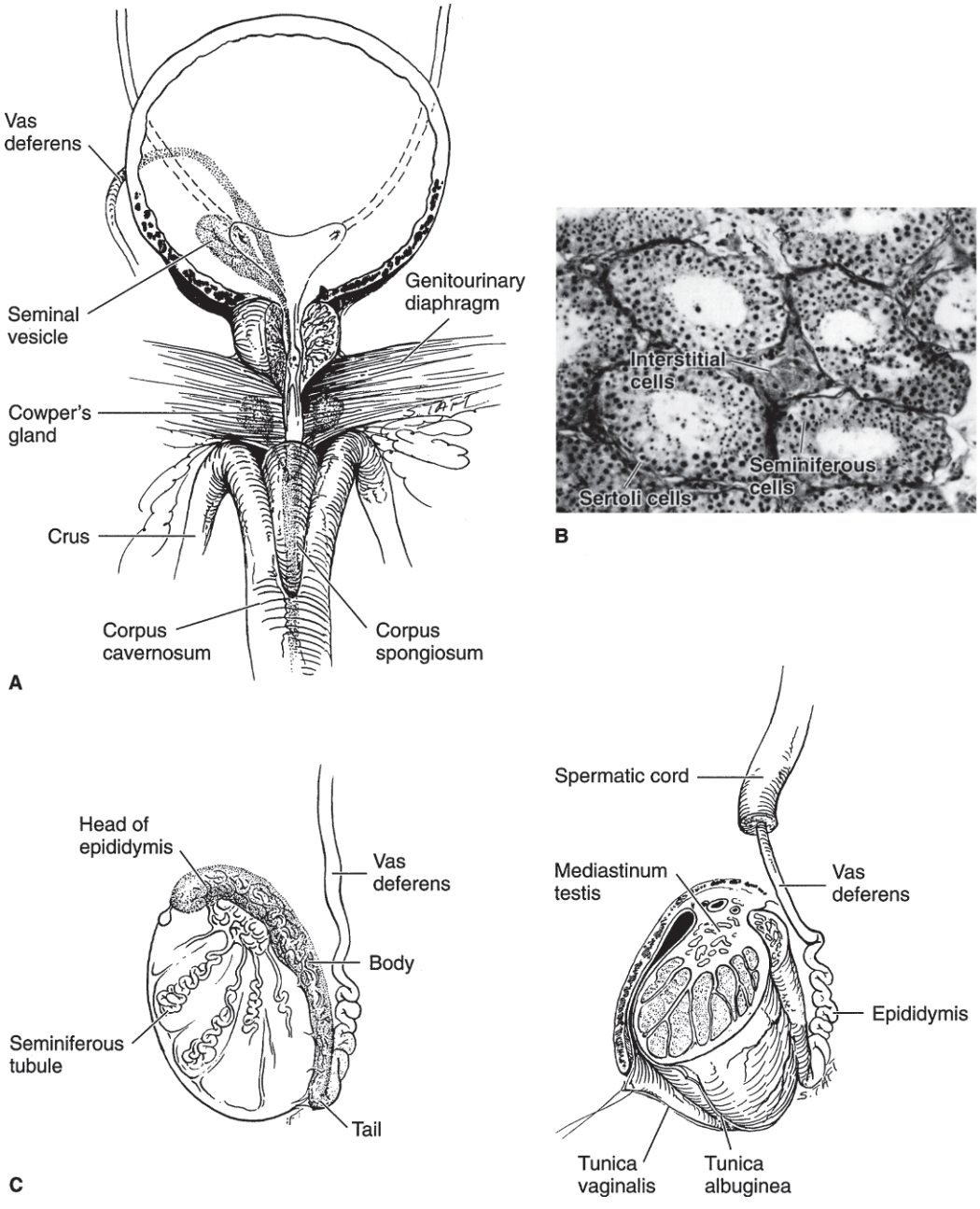
PROSTATE GLAND

Gross Appearance

A. Anatomy

The prostate is a fibromuscular and glandular organ lying just inferior to the bladder (Figures 1–6 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 (Figure 1–6). 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 (Figure 1–11).

The prostate can be subdivided into two ways: by lobe or by zone. The lobe classification is often used in cystourethroscopic examinations and consists of five lobes: anterior, posterior, median, right lateral, and left lateral. The zone classification is often used in pathology. McNeal (1981) divides the prostate into four zones: peripheral zone, central zone (surrounds the ejaculatory ducts), transitional zone (surrounds the urethra), and anterior fibromuscular zone (Myers et al, 2010) (Figure 1–12). 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



▲ **Figure 1–7.** ***(A)*** Anatomic relationship between the bladder, prostate, prostatomembranous urethra, and root of the penis. ***(B)*** 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. ***(C)*** Cross sections of the testis and epididymis. (Images [A] and [C] reproduced with permission from Walsh PC, Campbell MF: Campbell's Urology, 6th ed. Philadelphia, PA: Saunders; 1992.)