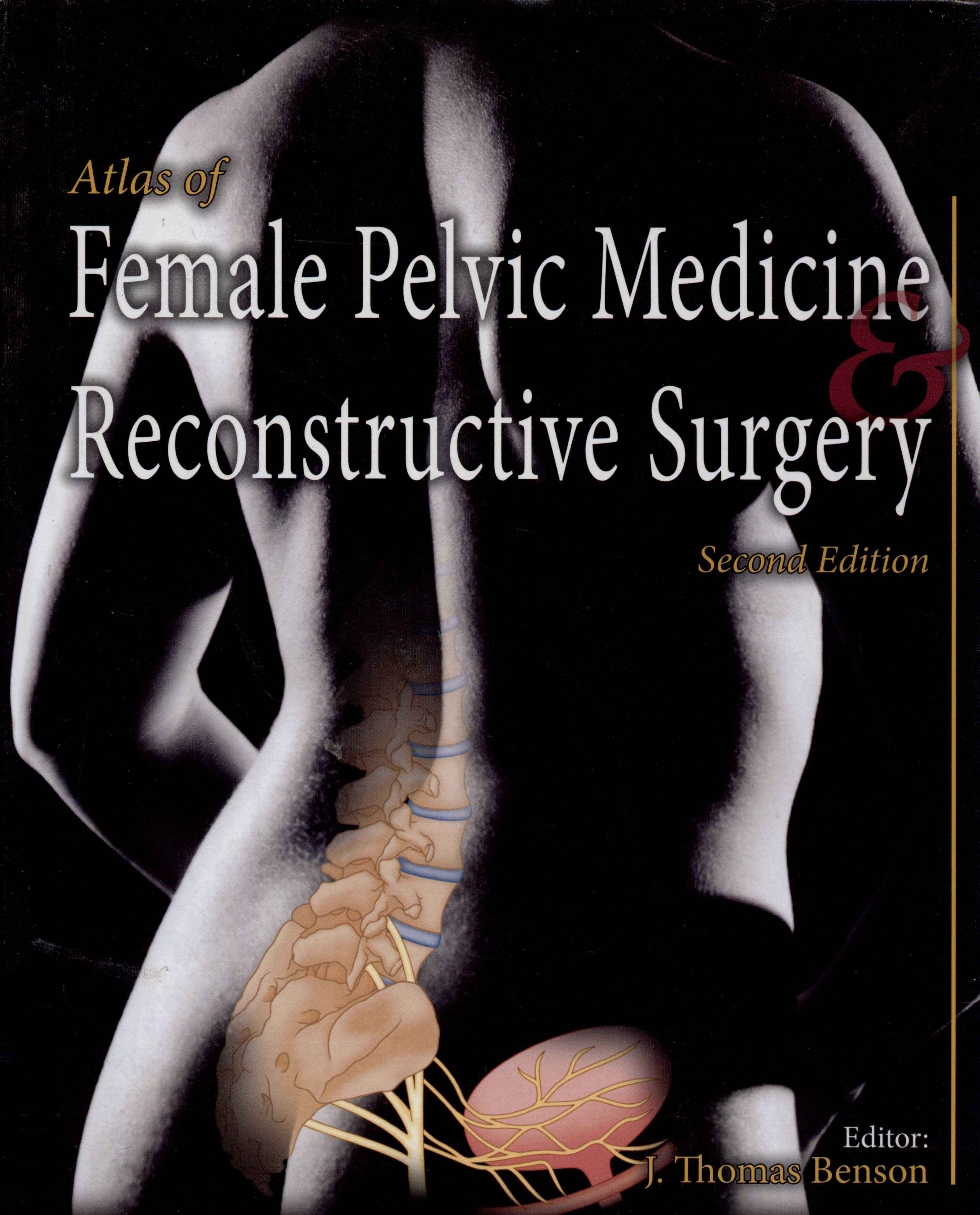

Atlas of

Female Pelvic Medicine & Reconstructive Surgery

Second Edition

Editor:
J. Thomas Benson

Atlas of Female Pelvic Medicine and Reconstructive Surgery

Second Edition

Editor

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Preface

During the preparation of this atlas, the editor, Dr. J. Thomas Benson, passed away after a 4-year bout with pancreatic cancer. His chapters in this text represent his last work and will serve as a reminder of his many contributions to the field. Dr. Benson was a pioneer in the field of female pelvic medicine and reconstructive surgery who, despite his diagnosis, remained active in patient care and fellow teaching.

Dr. Benson led a full and distinguished career in the field of medicine. He served as chairman and residency program director at Methodist Hospital in Indianapolis for over 20 years. In 1988, Dr. Benson started a fellowship in urogynecology. He, along with the other pioneers in this field, recognized the need for improved care for women with pelvic floor disorders and he dedicated the rest of his life to this mission. In 1996, the American Board of Obstetrics and Gynecology recognized Dr. Benson's program as the first to receive board accreditation in the country. Dr. Benson graduated 18 fellows from this program, the statistic of which he was most proud. He shared his knowledge with others readily and enjoyed helping numerous physicians across the country develop their professional careers.

He served in numerous professional positions including president of American Urogynecologic Society (AUGS) from 1991 to 1992, clinical professor at Indiana University School of Medicine, Advisory Board member for the International Society of Pelvic Neuromodulation, Task Force member of the American Association of Electrodiagnostic Medicine, World Health Organization Committee Member for Definition of Clinical Neurophysiology of the Pelvic Floor, Associate Editor of the International Urogynecology Journal, reviewer for numerous specialty journals, grant reviewer for NIDDK in 2000, American College of Surgeons Advisory Council for Obstetrics and Gynecology member, AUGS Board of Directors and Executive Committee, and United Methodist Children's Home board member, to name but a few. He was sought after as a national and international speaker and enjoyed these opportunities to share his knowledge.

Perhaps what best defined Dr. J. Thomas Benson was his natural curiosity, vision, and passion. Unsatisfied that pelvic floor disorders were the result of simple "defects" in connective tissue, Dr. Benson sought to define the pathophysiology of prolapse and incontinence. He dedicated his later career to the neurodiagnostic evaluation of the pelvis. He progressed from "simple" studies such as pudendal nerve terminal motor latencies to complex pelvic neurophysiologic reflex evaluations and somatosensory-evoked potentials. He became an international expert in needle electromyography of the pelvis and its related pathology. At a time when stress incontinence was thought to be a condition of urethral displacement, Dr. Benson argued the role of the urethral sphincter and its function as the core pathology in stress incontinence. Likewise, he looked at the levator ani and its dysfunction as the key to women who developed prolapse. He was integral to our understanding of the innervation of the pelvis from both autonomic and somatic views. Although these concepts were initially unpopular, they have become widely accepted in the etiology of prolapse and incontinence. Determined to further his understanding of electrodiagnostic medicine and to legitimize his research, in 1995, at the age of 61, Dr. Benson completed a fellowship in clinical neurophysiology at the Mayo Clinic in Rochester, Minnesota. He became the first and only ob-gyn to become boarded in Electrodiagnostic Medicine.

In addition to his neurophysiologic contributions, early on Dr. Benson discussed issues of fecal incontinence and bowel evacuation problems as an underrecognized component of pelvic floor disorders. At a time when neither patients nor physicians felt comfortable addressing these issues, he was outspoken about the need to discuss these issues with patients.

Of his over 70 peer-reviewed publications, Dr. Benson is perhaps best known for his prospective randomized trial comparing vaginal to abdominal surgery for the treatment of pelvic organ prolapse, the first such study to be completed. A master vaginal surgeon who believed vaginal surgery is what separated gynecologists from general surgeons, Dr. Benson was surprised and somewhat disappointed at the results showing superior outcomes with abdominal surgery. Nonetheless, armed with his results, he informed the medical community of his findings. He won the Society of Gynecologic Surgeons prize paper with this research and often defended his study in lively debates.

Away from medicine, Dr. Benson will be remembered by many in our field for his love of life. He was an avid motorcyclist, owning several Harley Davidsons before their resurgence. His dancing at national and international meetings will be missed as will his challenging of members to different athletic competitions. He was an avid lover of music and played both the guitar and piano. He was an outdoorsman who did not forget the practical lessons learned while being raised on a farm. He was always reading, eager to expose himself and others to new ideas.

Dr. Benson truly believed in the power of teaching and sharing of knowledge as the way to improve patient care. He was disappointed when others with the potential did not dedicate themselves to these same ideals. This text and its contributors represent the ideas and people Dr. Benson believed in. We can best honor Dr. Benson by continuing to push our field forward and challenge current concepts in order to improve patient care.

We all feel a loss with the passing of a person of his stature. We were very fortunate to have him in our field and in our lives. We became better physicians because of him, and our patients received better care through his efforts.

Douglass S. Hale

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Contents

1 Anatomy

John O. L. DeLancey

Muscles and connective tissues support the pelvic organs by attaching them to the bony pelvis. In women who have pelvic organ prolapse and incontinence, damage to these muscles and fibrous structures results in descent of the vaginal walls and pelvic organs through the urogenital hiatus in the levator ani muscles. Different types of prolapse exist in different women. One woman may have a cystocele, while another may have a cystocele and rectocele. The site at which a muscle or fascia is damaged determines the type of prolapse present. Of course, understanding the nature of these different clinical problems must be based on an accurate understanding of the site and type of defect present. The supportive apparatus that holds the pelvic organs in place was designed to operate in the standing position. This is the orientation in which the pelvic organ supports must be studied and understood. Physicians learn about pelvic anatomy from observing supine cadavers and by examining women in the clinic and operating department who are recumbent. This is somewhat like trying to understand how a parachute works while observing it lying crumpled on the ground. In considering the following anatomy, the reader should keep in mind the anatomic and topographic relationships as they exist under the effects of gravity in the standing individual.

Anatomy is the basic science of reconstructive pelvic surgery. This chapter is intended to provide a view of pelvic anatomy useful to clinicians who wish to understand the nature of pelvic organ prolapse. It is based on illustrative material taken directly from dissections of female cadavers supplemented with macroscopic and microscopic examination of serial sections containing the whole pelvis. Special techniques have been used to minimize embalming artifacts. Careful attention to the illustrations should provide a framework for understanding the clinical topics that follow.

The Bony Pelvis and Borders of the Pelvic Floor

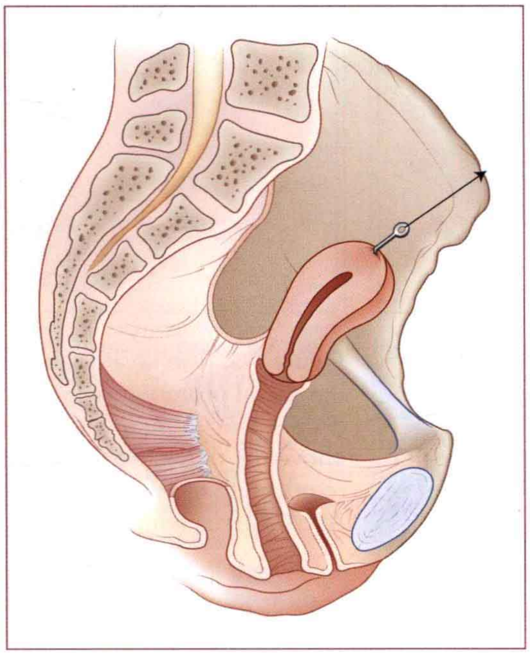

Figure 1-1. Compartments of the pelvis. The pelvis is divided into an anterior and posterior compartment by the vagina and its attachments to the pelvic wall. The walls of the posterior compartment are formed by the sacrum and levator ani muscles. The pubic bones, internal obturator muscles, and the anterior projection of the levator ani muscles form the walls of the anterior compartment. The walls of the vagina are attached to the pelvic walls by the endopelvic fascia and form the separating wall that divides the anterior and posterior compartments.

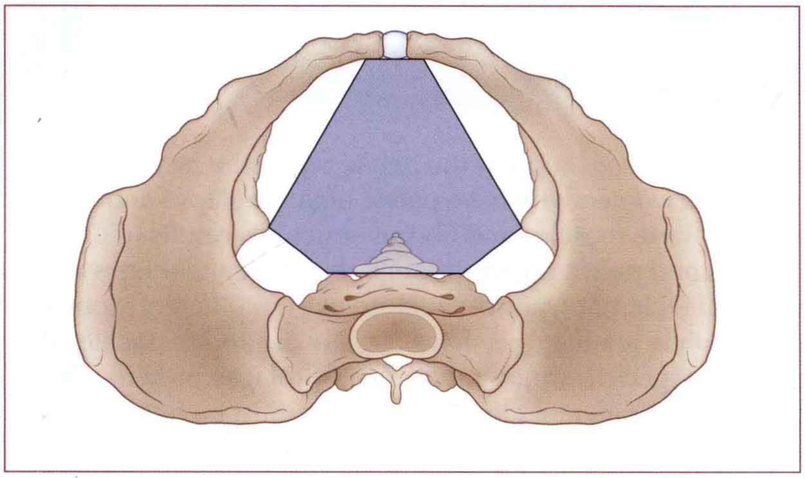

Figure 1-2. Space occupied by the pelvic floor. The boundaries of the pelvic floor are hexagonal. The ventral bounds are the pubic bones anteriorly, the arcus tendinei laterally, and the sacrum and sacrospinous ligaments dorsally. The ischial spines form the lateral points of attachment for both the sacrospinous ligament and the arcus tendinei.

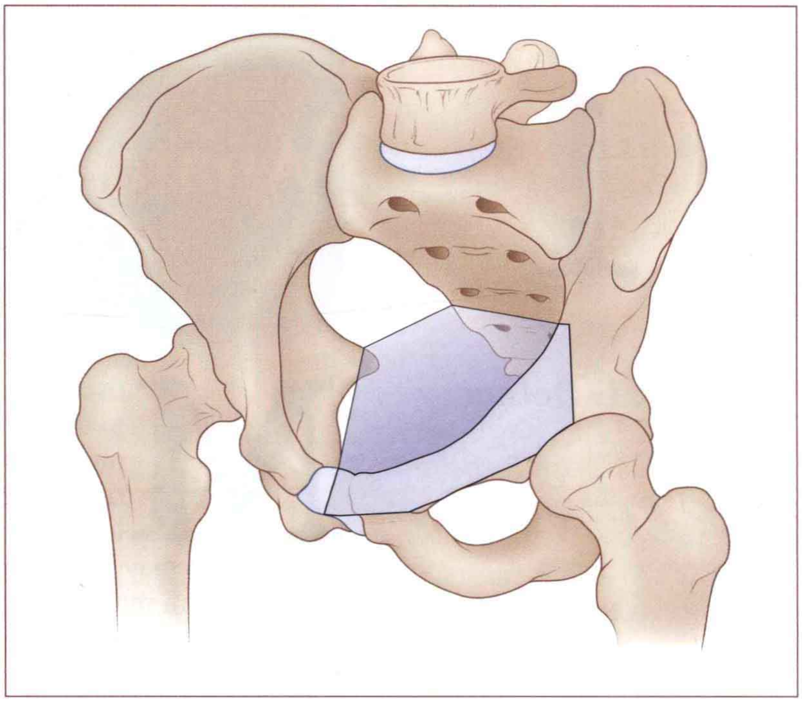

Figure 1-3. Pelvic plane. The plane of the pelvic floor lies oblique to the horizontal plane in the standing position.

Levator Ani Muscles and Endopelvic Fascia

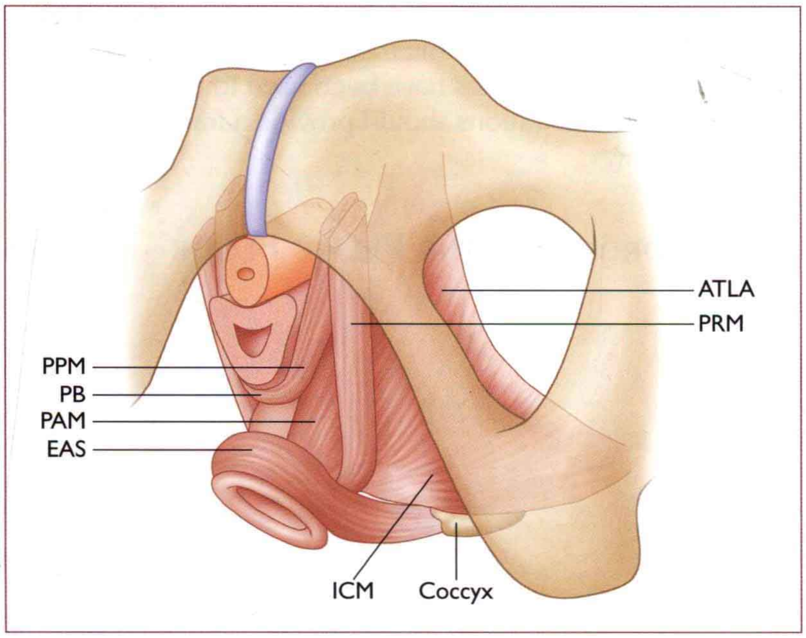

Figure 1-4. Levator ani muscles from below after the vulvar structures and perineal membrane have been removed, showing the arcus tendineus levator ani (ATLA), external anal sphincter (EAS), puboanal muscle (PAM), perineal body (PB) uniting the two ends of the puboperineal muscle (PPM), iliococcygeal muscle (ICM), and puborectal muscle (PRM). Note that the urethra and vagina have been transected just above the hymenal ring.

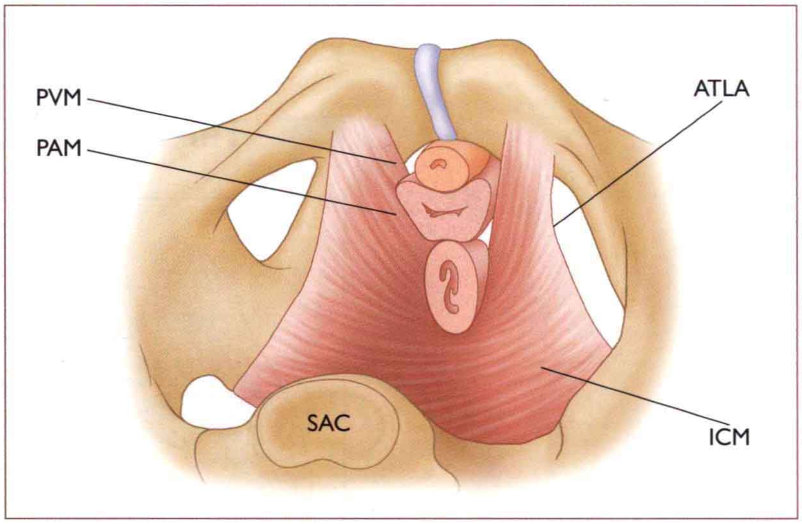

Figure 1-5. The levator ani muscle seen from above, looking over the sacral promontory (SAC) and showing the pubovaginal muscle (PVM). The urethra, vagina, and rectum have been transected just above the pelvic floor. The internal obturator muscles have been removed to clarify levator muscle origins. PAM—puboanal muscle; ATLA—arcus tendineus levator ani; ICM—iliococcygeal muscle.

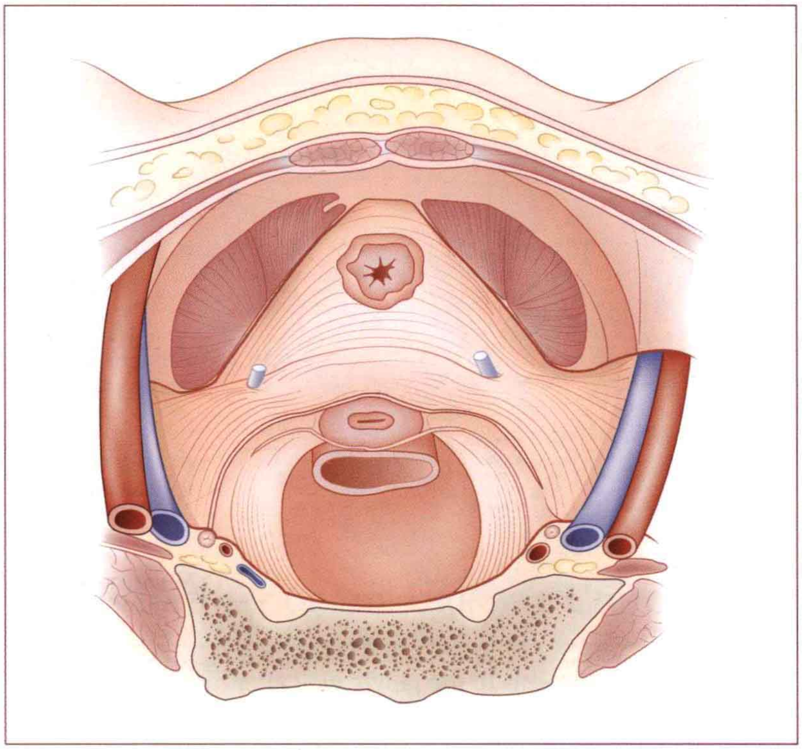

Figure 1-6. Fascial tissues of the pelvis. The fascial tissues that attach the cervix to the pelvic wall are shown from above after the removal of the uterine corpus. Note how the uterosacral ligaments are simply the medial margin of these tissues. Also note the lateral boundary of the pelvic floor formed by the tendinous arch of the pelvic fascia.

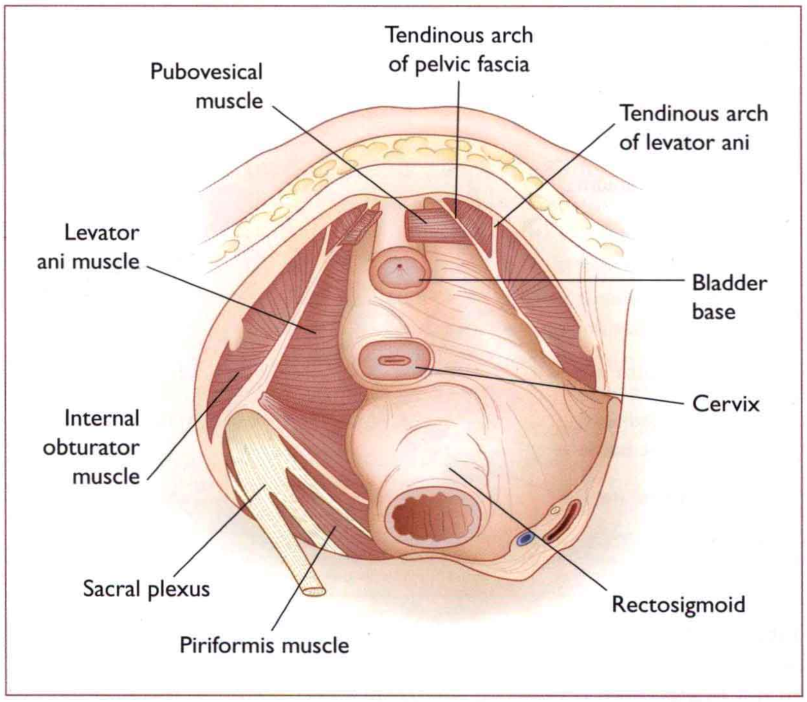

Figure 1-7. The right side of this dissection shows the endopelvic fascia's attachment to the pelvic walls. The other side reveals the position of the levator ani muscles below this level, as well as the nerves of the sacral plexus. Note the proximity of the sacral plexus of nerves to the sacrospinous ligament as they exit the pelvis through the greater sciatic foramen on the inner surface of the piriformis muscle. The boundaries of the pelvic floor, the arcus tendineus, and coccygeus muscle/sacrospinous ligament complex are visible on the cadaver's left side.

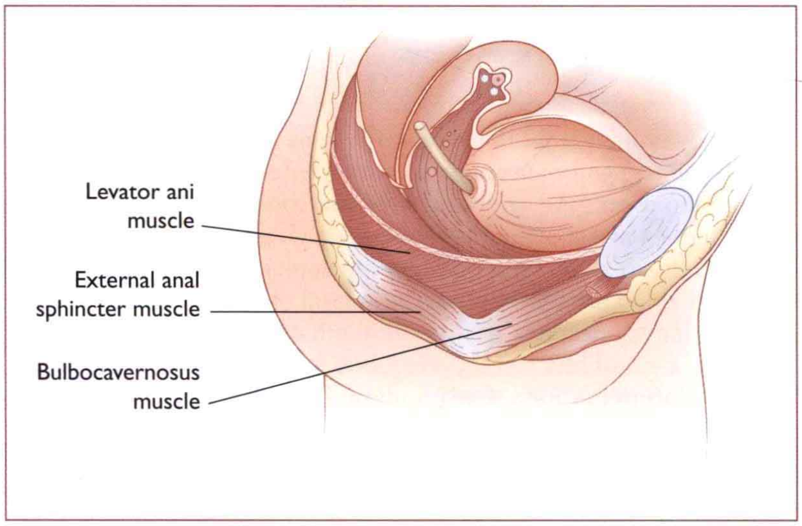

Figure 1-8. Lateral view of the pelvis. The relationship between the pelvic organs and the levator ani muscles is illustrated. A portion of each organ system (urinary, genital, and intestinal) lies above the levator ani muscles. Each system has an orifice below the muscles. As the viscera pass through the pelvic musculature, they are influenced in two ways. First, the sling of the levator ani muscles pulls them toward the pubic bones, constricting their lumens and preventing their downward descent through the attachment of the visceral walls and the muscles. Second, distal sphincters help occlude the lumens of each organ system.

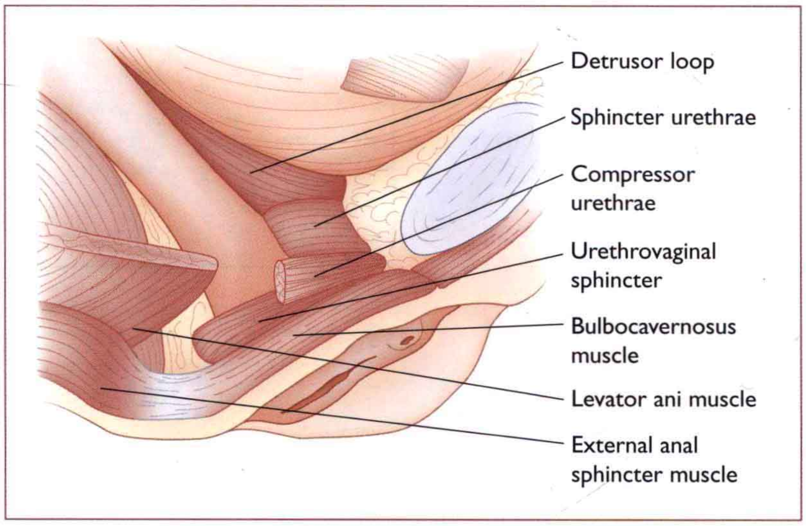

Figure 1-9. In this illustration, the anterior portion of the levator ani muscle has been removed to show the urogenital sphincter muscles. The striated urogenital sphincter muscle has two regions. Just below the vesical neck, the muscle encircles the urethra. Nearer the external meatus, two bands of muscle arch over the dorsal urethral wall. One band, the urethrovaginal sphincter muscle, encircles both the vagina and urethra while the other, the compressor urethra, passes laterally along the ischiopubic rami just cephalad to the perineal membrane (urogenital diaphragm).

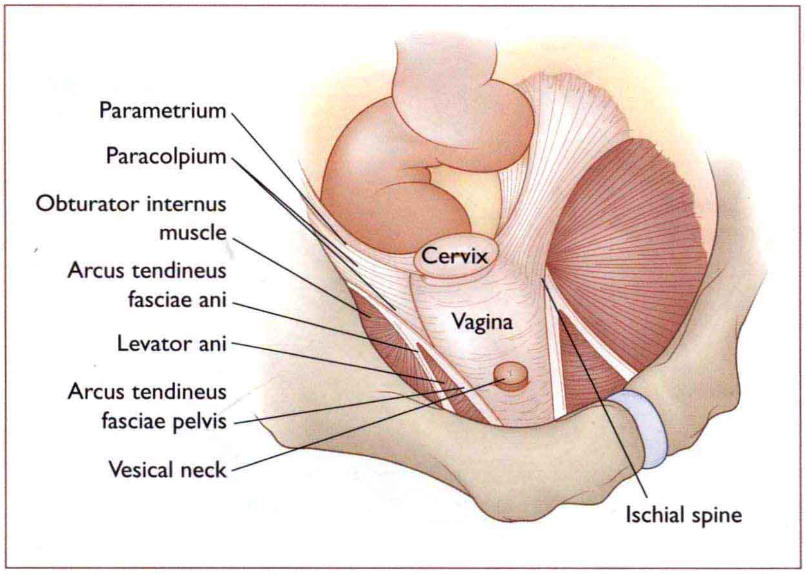

Figure 1-10. Fascial supports of the vaginal apex and anterior vaginal wall. This illustration demonstrates the regional differences in the fascial attachments of the vagina and cervix to the pelvic walls. The bladder and corpus of the uterus have been removed so only the vesical neck and cervix remain. Note that the fascial fibers near the cervix and upper vagina are vertical in orientation, while those attaching to the midvagina are transverse, spanning the space between the fascial arches. It is also possible to see divergence between the two fascial arches. The tendinous arch of the levator ani, from which the levator ani muscle arises, attaches higher on the pubic bone than the tendinous arch of the pelvic fascia, which is the structure to which the endopelvic fascia is attached.

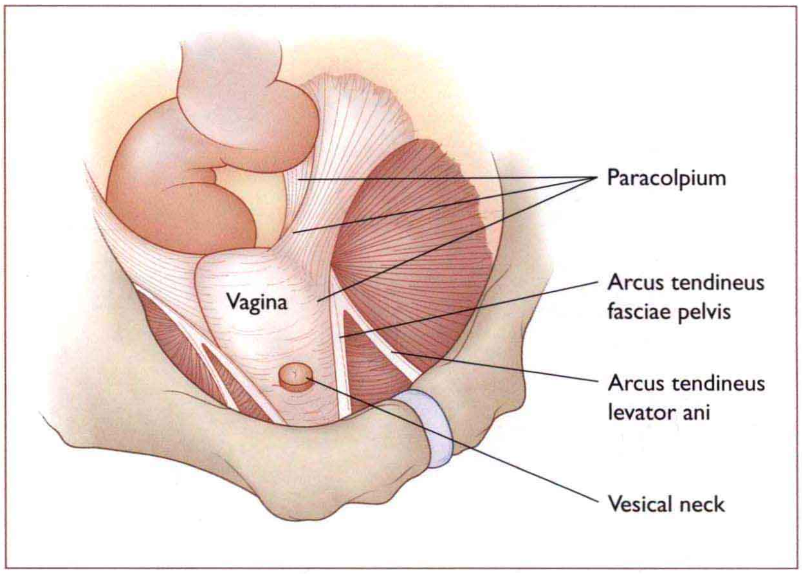

Figure 1-11. Attachments to the pelvic wall after hysterectomy. This figure reveals the situation that is present after hysterectomy. The upper vaginal supports differ from the midvaginal supports.

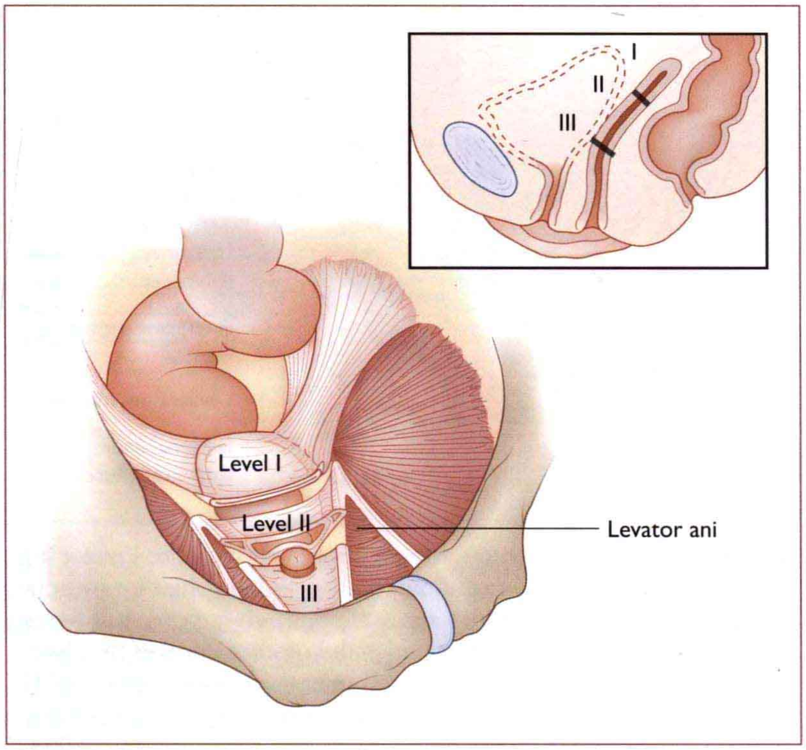

Figure 1-12. The attachments of the vagina to the pelvic walls can be divided into three regions. Note that despite the removal of the cervix, the fibers in level I, the long suspensory fibers of the paracolpium, suspend the upper vagina. In the midvagina, level II, the vagina is attached laterally to the tendinous arch of the pelvic fascia. Level III is characterized by fusion of the vagina to surrounding structures.

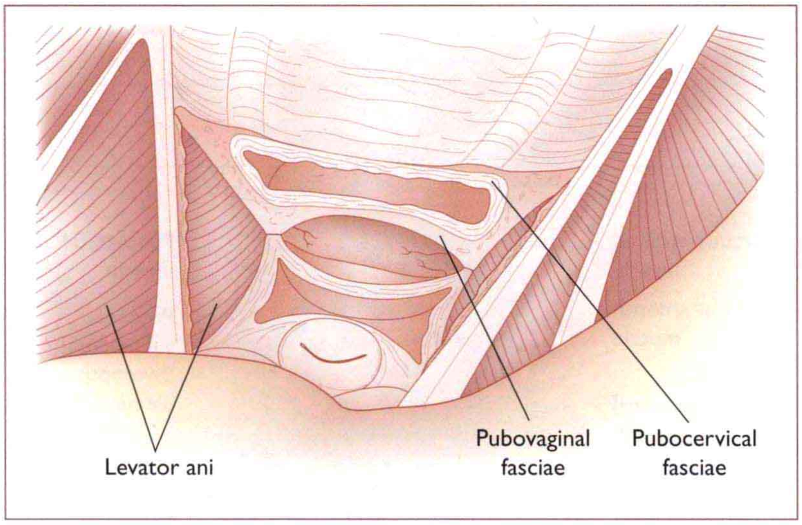

Figure 1-13. Nature of level II. This view shows the caudal margin of level II after a triangular wedge of the vaginal wall has been removed, which exposes the distal urethra and the anterior surface of the rectum. The fascial attachment between the anterior vaginal wall and the tendinous arch of the pelvic fascia is visible. The structural layer on which the bladder rests is comprised of the vaginal wall and its connections through the pubocervical fascia to the arcus. At this level of the vagina, there is no separate layer that separates the vagina from the bladder. It is the wall of the vagina itself that is responsible for bladder base support.

Anatomy of the Urinary Continence Mechanism

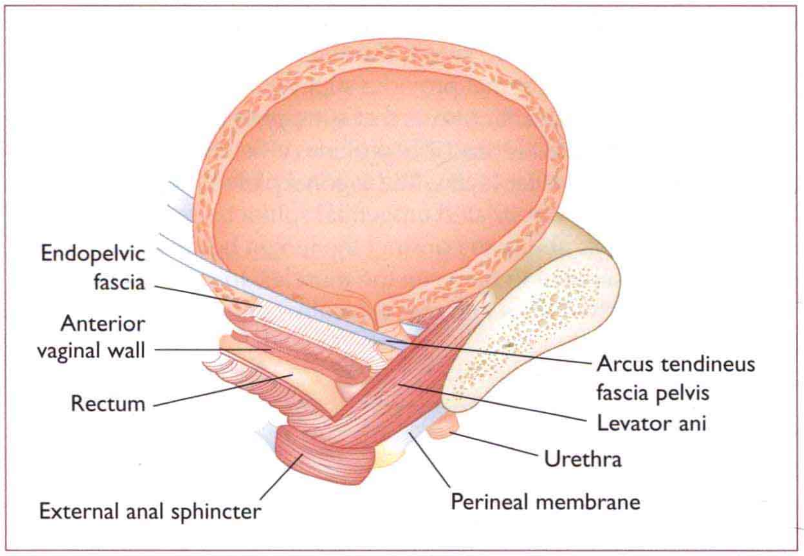

Figure 1-14. The lateral view of the pelvic floor structures related to urethral support is seen from the side in the standing position, cut just lateral to the midline. Note that windows have been cut into the levator ani muscles, vagina, and endopelvic fascia so that the urethra and anterior vaginal walls can be seen. Note that the tendineus arch of the pelvic fascia is stretched from the pubic bone to its eventual attachment to the ischium. The anterior vaginal wall is attached to the arcus by the endopelvic fascia and forms a supportive layer for the bladder and urethra. The levator ani muscle attaches to the endopelvic fascia so that contraction of the levator muscle can elevate the urethra.

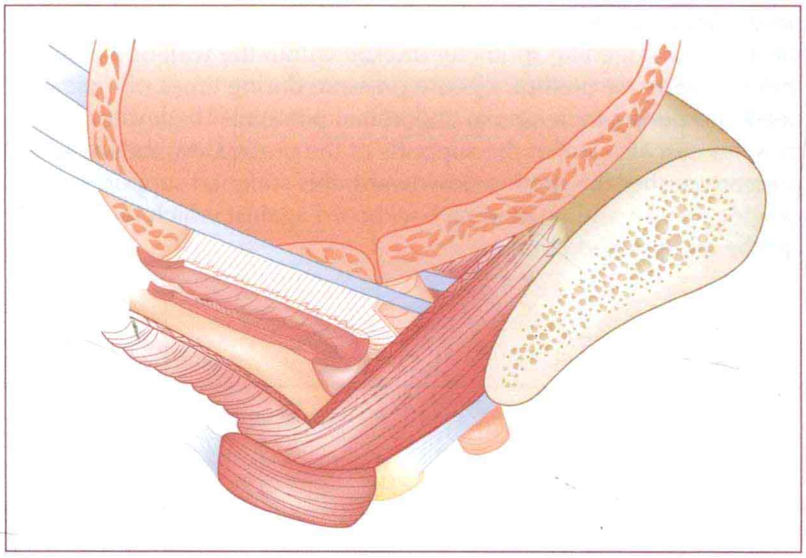

Figure 1-15. Closeup view of the urethral support structures shown in Figure 1-14.

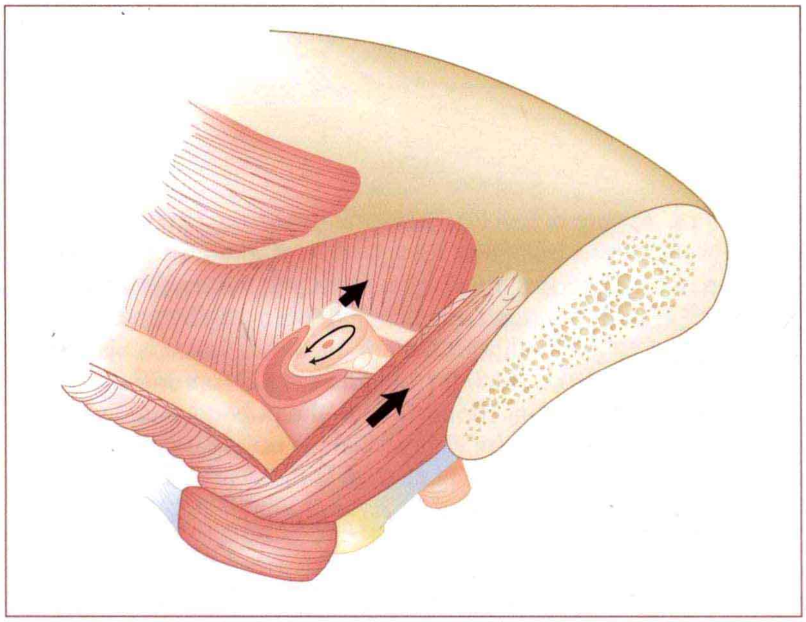

Figure 1-16. There are two ways in which the striated muscles of the pelvic floor can affect urinary continence. The constrictive effects of the striated urogenital sphincter muscle within the wall of the urethra can increase urethral closure pressure during times of increased need and during increases in abdominal pressure. The levator ani muscles can also stiffen the supports of the urethra. As abdominal pressure pushes the urethra downward, this stiffened support system provides a firm and unyielding backboard against which the urethra can be compressed closed.

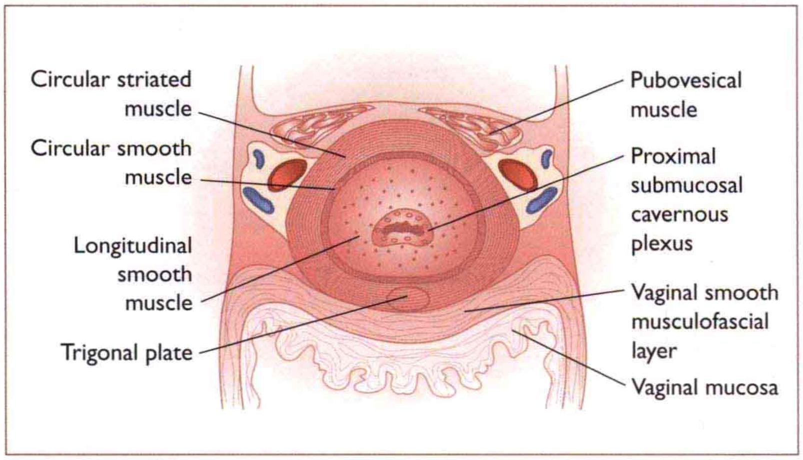

Figure 1-17. Structures seen in the midurethra. Here the striated muscle of the urethra can be seen to surround the circular and longitudinal smooth muscle layers. The submucosal vaginal musculofascial layer is the layer that provides support for the urethra. Note also the prominent vascular plexus that surrounds the mucosal lining of the urethra. This plexus probably provides a flexible filling between the mucosa and muscular layers. The trigonal plate bridges the gap between the ends of the striated urogenital sphincter muscle. This gap does not impede its ability to constrict the lumen because the trigonal plate spans the separation between the muscles, forming a tendon-like union of the two sides and mechanically connecting them.

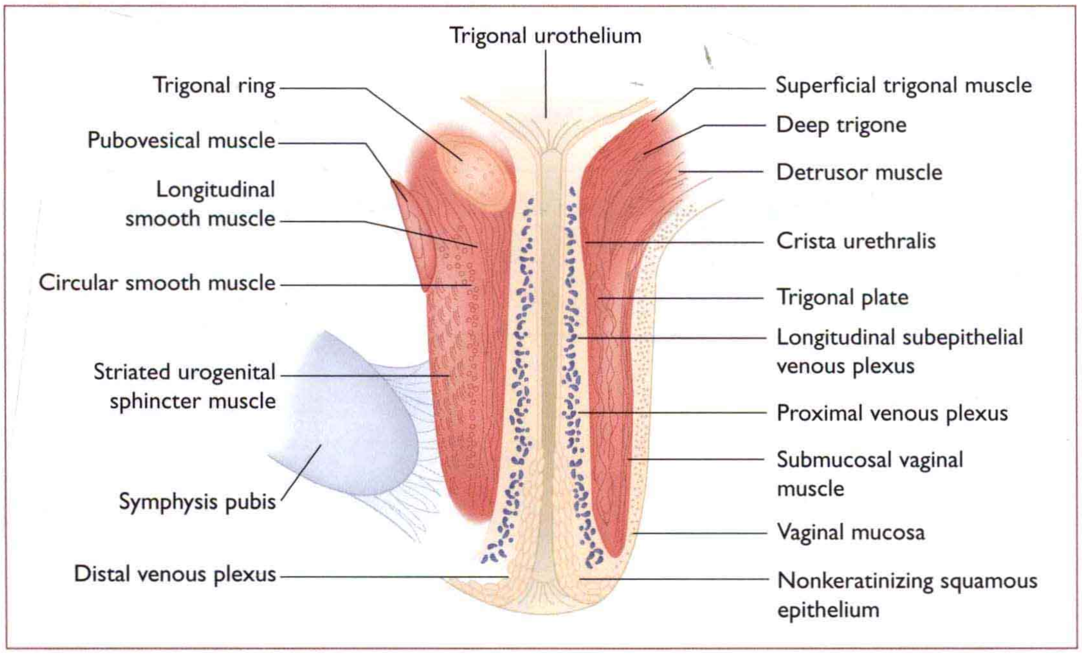

Figure 1-18. The layered structure of the urethral wall can be seen in sagittal section. Just below the internal urinary meatus, the urethral lumen is surrounded by muscle that forms the bladder. The trigonal ring anteriorly marks the most caudal extent of the bladder. Inserting into the vesical neck in the dorsal wall of the urethra are fibers of the detrusor muscle that probably act to help open the vesical neck when the detrusor muscle contracts. The striated urogenital sphincter muscle begins below the vesical neck and extends along the midurethra. The pubovesical muscle is an extension of the detrusor muscle that passes laterally to attach the bladder muscle to the tendinous arch of the pelvic fascia and may also be involved in vesical neck opening at the beginning of micturition.

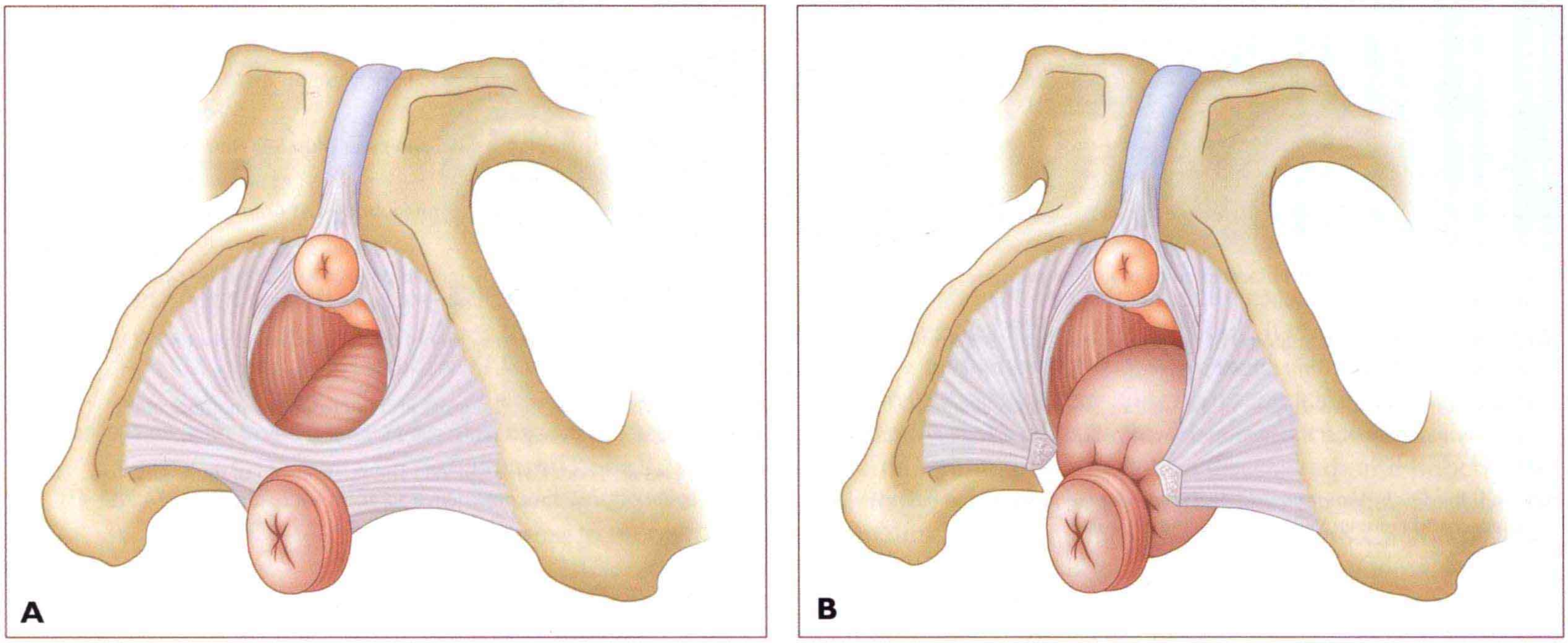

Figure 1-19. **A**, The perineal membrane spans the arch between the ischiopubic rami with each side attached to the other through their connection in the perineal body. **B**, Note that separation of the fibers in this area leaves the rectum unsupported and results in a low posterior prolapse.

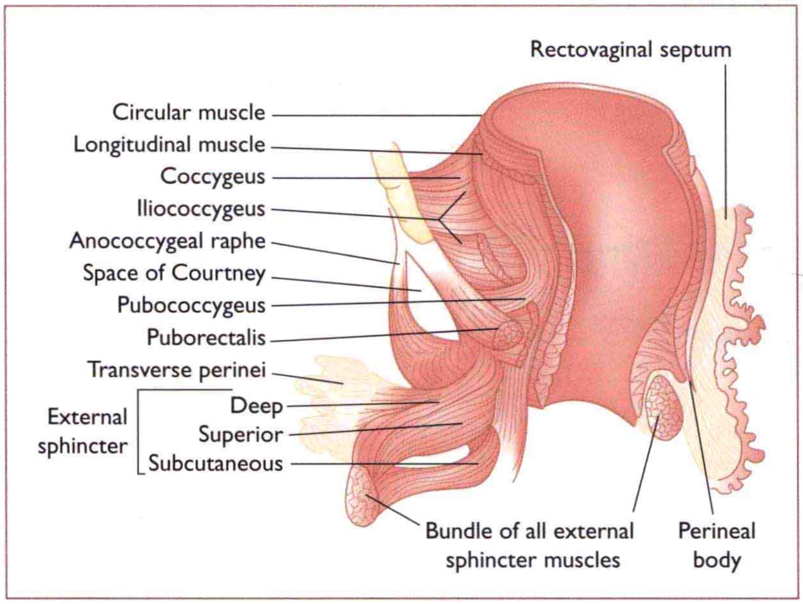

Figure 1-20. This lateral view of the anal sphincters reveals their important relationships. Note that the internal anal sphincter extends down to overlap the external anal sphincter so that a fourth degree laceration of the perineum during vaginal delivery must transect the internal sphincter as well as the external sphincter. Note also that the puborectalis muscle lies cephalic to the external sphincter behind the anorectum at the anorectal angle. Note that the pubococcygeus muscle lies cephalic to the puborectalis and to the iliococcygeus muscle. The anal sphincter complex is attached to the coccyx by the anococcygeal raphe.

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2 Congenital Anomalies of the Female Genital Tract

Renee M. Caputo

The urogenital system develops from the intermediate mesoderm, the coelomic epithelium, and the endoderm of the urogenital sinus. It consists of the urinary (excretory) system and the genital (reproductive) system. Although the urinary system develops first, the two systems are closely associated embryologically and, thus, also anatomically. Anomalies of the female external genitalia are diagnosed at birth, while other internal anomalies may not be discovered until puberty, the onset of menstruation, or sexual activity; this puts the gynecologist in a unique position to be the first to recognize these anomalies, which can have devastating physical and psychological consequences. This chapter will review the basic embryology of the female genital tract with references to the urinary tract when appropriate. The more common anomalies of the female genital tract are then presented, along with the diagnostic tools and treatment options that are necessary to manage them.

Normal Embryologic Development of the Female Genital Tract

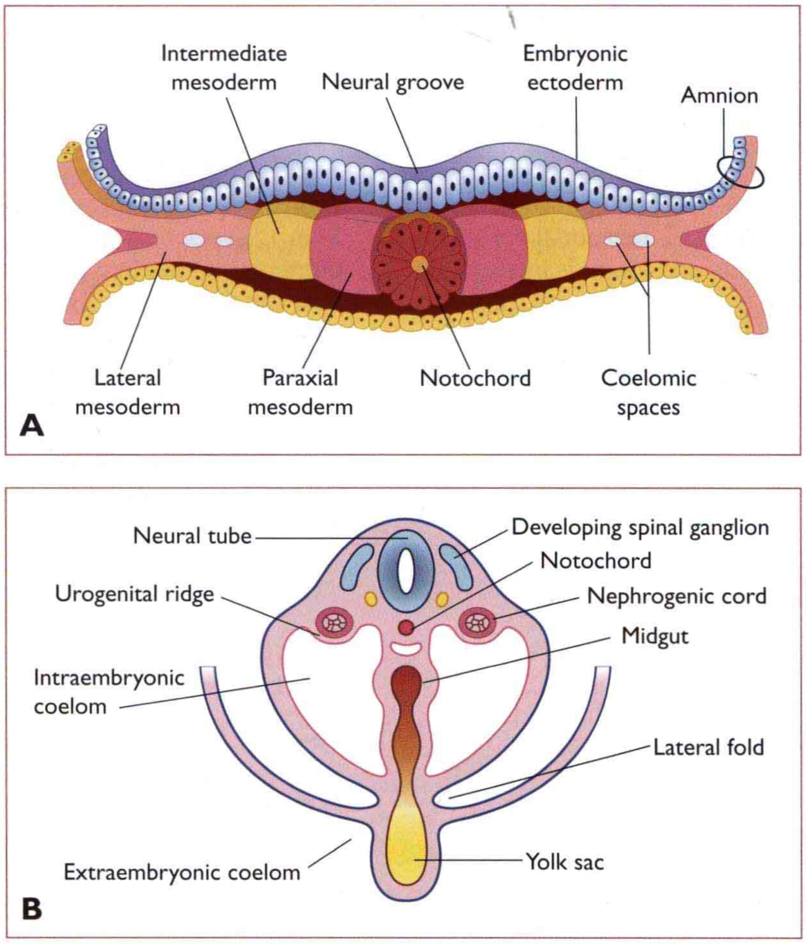

Figure 2-1. Urogenital ridges. Dorsal folding of an embryo at approximately 18 days. **A,** The urogenital system develops from the intermediate mesoderm along the dorsum of the embryo. **B,** With transverse folding of the embryo during the 4th week (at approximately 24 days), the intermediate mesoderm migrates ventrally. This bilateral longitudinal mass of mesoderm is called the nephrogenic cord. These cords produce longitudinal bulges, the urogenital ridges, on the dorsal wall of the intraembryonic coelomic cavity. The urogenital ridges become both renal and genital structures. (*Adapted from* Moore and Persaud [1].)