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Justin A. Maykel · Thomas E. Read
Charles B. Whitlow *Editors*

The ASCRS Manual of Colon and Rectal Surgery

Third Edition

Springer

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Editors
Scott R. Steele
Department of Colorectal Surgery
Cleveland Clinic
Cleveland, OH
USA

Neil Hyman
Section of Colon and Rectal Surgery
University of Chicago Medicine
Chicago, IL
USA

Thomas E. Read
Division of Gastrointestinal Surgery
University of Florida College of Medicine
Gainesville, FL
USA

Tracy L. Hull
Department of Colorectal Surgery
Cleveland Clinic
Cleveland, OH
USA

Justin A. Maykel
Division of Colon and Rectal Surgery
University of Massachusetts Memorial Medical Center
Worcester, MA
USA

Charles B. Whitlow
Department of Colon and Rectal Surgery
Ochsner Medical Center
New Orleans, LA
USA

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Preface

In continuation with the first two volumes, the third edition of the American Society of Colon and Rectal Surgeons' (ASCRS) Manual is again abstracted from and a companion to the third edition of the *ASCRS Textbook of Colon and Rectal Surgery* (Steele, Hull, Read, Saclarides, Senagore, Whitlow, eds. New York: Springer, 2016). The manual serves as a readily available, easy-to-access, and succinct resource for all providers caring with colorectal disease.

The collective goal for the third edition of the *ASCRS Textbook of Colon and Rectal Surgery* was to provide a valuable resource for surgeons and health-care providers who care for patients with colorectal disease at all stages of their careers. In line with previous editions, we aimed to build upon the collective experience and expertise from national and international experts in the field, providing a completely revamped, up-to-date tome covering the wide breadth of colorectal disease organized around the "pillars" of colorectal surgery including perioperative care (including endoscopy), anorectal disease, benign disease (including inflammatory bowel disease), malignancy, pelvic floor disorders, and a "miscellaneous" section that covers aspects both inside and beyond the operating room that are pertinent to providers at every level. In addition, each chapter contains several *key concepts* that succinctly depict the major learning objectives for individual sections and are in line with the Core Curriculum for Colon and Rectal Surgery provided by the Association of Program Directors in Colon and Rectal Surgery and the key topics used by the American Board of Colon and Rectal Surgery.

Each chapter in the manual has been abstracted, edited, and reviewed by the textbook authors and manual editors. Many diagrams, figures, and algorithms have been retained from the textbook, as they are felt to help with patient care. In an effort to continue to build and expand upon the education platform across the ASCRS, the manual serves as a bridge between the journal (*Diseases of the Colon and Rectum*), the ASCRS textbook, and other resources such as CARSEP and CREST. Further information, including more in-depth technical, scientific, and expert opinion, as well as references, are available and can always be accessed through any of our other resources and

programs. It is our sincere wish that this manual will serve as a relevant and practical tool to provide information and recommendations and ultimately help improve the care and outcome for our patients.

Cleveland, OH, USA — Scott R. Steele, MD
Cleveland, OH, USA — Tracy L. Hull, MD
Chicago, IL, USA — Neil Hyman, MD
Worcester, MA, USA — Justin A. Maykel, MD
Gainesville, FL, USA — Thomas E. Read, MD
New Orleans, LA, USA — Charles B. Whitlow, MD

Contents

Contributors

Cary B. Aarons, MD Division of Colon and Rectal Surgery, Hospital of the University of Pennsylvania, Philadelphia, PA, USA

Maher A. Abbas, MD, FACS, FACRS Al Azhra Hospital Dubai, Dubai, UAE

Karim Alavi, MD, MPH Department of Surgery, University of Massachusetts Medical School, Worcester, MA, USA

Dennis K. Ames, JD La Follette, Johnson, Dehaas, Fesler & Ames, Santa Ana, CA, USA

Glenn T. Ault, MD, MSEd Division of Colorectal Surgery, Department of Surgery, University of Southern California, Los Angeles, CA, USA

Jennifer M. Ayscue, MD, FACS, FASCRS Section of Colon & Rectal Surgery, Department of Surgery, MedStar Washington Hospital Center, Washington, DC, USA

Amir L. Bastawrous, MD, MBA, FACS, FASCRS Swedish Cancer Institute, Swedish Colon and Rectal Clinic, Seattle, WA, USA

Joshua I. S. Bleier, MD, FACS, FASCRS Department of Surgery, Hospital of the University of Pennsylvania/Pennsylvania Hospital, Philadelphia, PA, USA

Liliana Bordeianou, MD, MPH Department of General Surgery, Massachusetts General Hospital, Boston, MA, USA

Raul Martin Bosio, MD, MSBS ProMedica Physicians General Surgery, Sylvania, OH, USA

W. Donald Buie, MD, MSc, FRCSC, FACS, FASCRS Department of Surgery, Foothills Medical Centre, University of Calgary, Calgary, AB, Canada

Jamie A. Cannon, MD Division of Gastrointestinal Surgery, Department of Surgery, University of Alabama at Birmingham, Birmingham, AL, USA

Evie H. Carchman, MD Department of Surgery, University of Wisconsin – School of Medicine and Public Health, Madison, WI, USA

Joseph C. Carmichael, MD Department of Surgery, University of California, Irvine, Orange, CA, USA

Peter A. Cataldo, MD, FACS, FASCRS Department of Surgery, University of Vermont Medical Center, University of Vermont College of Medicine, Burlington, VT, USA

Thomas E. Cataldo, MD, FACS, FASCRS Division of Colon and Rectal Surgery, Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Andrea Cercek, MD Department of Medicine, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Bradley J. Champagne, MD, FACS, FASCRS Fairview Medical Center, Cleveland, OH, USA

Department of Colorectal Surgery, Cleveland Clinic, Cleveland, OH, USA

George J. Chang, MD, MS Department of Surgical Oncology, The University of MD Anderson Cancer Center, Houston, TX, USA

Dorin T. Colibaseanu, MD Department of Surgery, Mayo Clinic, Rochester, MN, USA

Kyle G. Cologne, MD Department of Surgery, Division of Colorectal, University of Southern California Keck School of Medicine, Los Angeles, CA, USA

Tara M. Connelly, MD, MB, BCh, MSc Department of Colorectal Surgery, University Hospital Limerick, Limerick, Ireland

Jennifer S. Davids, MD Department of Surgery, University of Massachusetts Memorial Medical Center, Worcester, MA, USA

Bradley R. Davis, MD, FACS, FASCRS Department of Surgery, Section of Colorectal Surgery, Atrium Health, Carolinas Medical Center, Charlotte, NC, USA

Kurt Davis, MD Department of Surgery, Lousiana State University Health School of Medicine, New Orleans, LA, USA

Conor P. Delaney, MD, PhD Department of Colorectal Surgery, Digestive Disease Institute, Cleveland Clinic, Cleveland, OH, USA

Eric J. Dozois, MD Department of Surgery, Mayo Clinic, Rochester, MN, USA

Jonathon Efron, MD Department of Surgery, Johns Hopkins Hospital, Johns Hopkins University, Baltimore, MD, USA

Peter F. Ehrlich, MD, MSc Section of Pediatric Surgery, University of Michigan C.S. Mott Children's Hospital, Ann Arbor, MI, USA

Marwan Fakih, MD Department of Medical Oncology and Therapeutic Diagnostics, City of Hope Medical Center, Duarte, CA, USA

Daniel L. Feingold, MD, FACS, FASCRS Department of Surgery, Columbia University, New York, NY, USA

Alessandro Fichera, MD, FACS, FASCRS Department of Surgery, University of North Carolina, Chapel Hill, NC, USA

Todd D. Francone, MD, MPH Department of General Surgery, Section of Colorectal Surgery, Massachusetts General Hospital, Boston, MA, USA

Charles M. Friel, MD, FACS, FASCRS Department of Surgery, University of Virginia Medical Center, Charlottesville, VA, USA

Wolfgang B. Gaertner, MSc, MD, FACS, FASCRS Department of Colon & Rectal Surgery, University of Minnesota, Minneapolis, MN, USA

Julio Garcia-Aguilar, MD, PhD Department of Surgery, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Kelly A. Garrett, MD, FACS, FASCRS Department of General Surgery, Section of Colon and Rectal Surgery, Weill Cornell Medical College, New York Presbyterian Hospital, New York, NY, USA

Stephen R. Gorfine, MD Division of Colorectal Surgery, Department of Surgery, The Mount Sinai Hospital, New York, NY, USA

Brooke Gurland, MD Colorectal Surgery, Stanford University, Stanford, CA, USA

Eric M. Haas, MD, FACS, FASCRS Division of Colon and Rectal Surgery, Houston Methodist Hospital, Houston, TX, USA

The University of Texas Medical School, Houston, TX, USA

LLP LTD, Houston, TX, USA

Jason Hall, MD, MPH, FACS, FASCRS Division of Colon and Rectal Surgery, Boston University Medical Center, Boston, MA, USA

Tufts University School of Medicine, Boston, MA, USA

Karin M. Hardiman, MD, PhD Division of Colorectal Surgery, University of Michigan, Ann Arbor, MI, USA

Dana M. Hayden, MD, MPH Department of General Surgery, Loyola University Medical Center, Maywood, IL, USA

Charles P. Heise, MD, FACS, FASCRS Department of Surgery, University of Wisconsin – School of Medicine and Public Health, Madison, WI, USA

Alan J. Herline, MD Department of Surgery, Georgia Regents University, Augusta, GA, USA

Daniel O. Herzig, MD, FACS, FASCRS Division of Gastroenterology and General Surgery, Department of Surgery, Oregon Health and Science University, Portland, OR, USA

Rebecca E. Hoedema, MS, MD, FACS, FASCRS Department of Colon and Rectal Surgery, Spectrum Health/Ferguson Clinic, Grand Rapids, MI, USA

Stefan D. Holubar, MD, MS, FACS, FASCRS Department of Colorectal Surgery, Cleveland Clinic, Cleveland, OH, USA

Tracy L. Hull, MD Department of Colorectal Surgery, Cleveland Clinic, Cleveland, OH, USA

Steven R. Hunt, MD Division of General Surgery, Section of Colon and Rectal Surgery, Department of Surgery, Barnes Jewish Hospital, Washington University School of Medicine, St. Louis, MO, USA

Neil Hyman, MD, FACS, FASCRS Section of Colon and Rectal Surgery, University of Chicago Medicine, Chicago, IL, USA

Eric K. Johnson, MD, FACS, FASCRS Department of Colorectal Surgery, Cleveland Clinic, Cleveland, OH, USA

Andreas M. Kaiser, MD, FACS, FASCRS Keck Medical Center of the University of Southern California, Los Angeles, CA, USA

Matthew F. Kalady, MD, FACS, FASCRS Department of Colorectal Surgery, Digestive Disease Institute, Cleveland Clinic, Cleveland, OH, USA

Brian R. Kann, MD, FACS, FASCRS Department of Colon and Rectal Surgery, Ochsner Medical Center, New Orleans, LA, USA

Muneera R. Kapadia, MD, MME Department of Surgery, University of Iowa Hospitals and Clinics, Iowa City, IA, USA

Kevin R. Kasten, MD Department of Surgery, Section of Colorectal Surgery, Atrium Health, Carolinas Medical Center, Charlotte, NC, USA

Brody School of Medicine, East Carolina University, Greenville, NC, USA

Gregory D. Kennedy, MD, PhD Department of Surgery, University of Alabama-Birmingham, Birmingham, AL, USA

Jason D. Keune, MD, MBA Department of Surgery, St. Louis University School of Medicine, St. Louis, MO, USA

Cindy J. Kin, MD, MS Department of Surgery, Stanford University School of Medicine, Stanford, CA, USA

P. Ravi Kiran, MBBS, MS Division of Colorectal Surgery, Department of Colorectal Surgery, Columbia University Medical Center and Mailman School of Public Health, New York, NJ, USA

Center for Innovation and Outcomes Research, New York Presbyterian Hospital/Columbia University Medical Center, New York, NY, USA

Walter A. Koltun, MD, FACS, FASCRS Department of Surgery, Division of Colon and Rectal Surgery, Milton S. Hershey Medical Center, Penn State College of Medicine, Hershey, PA, USA

Mukta K. Krane, MD, FACS Department of Surgery, University of Washington Medical Center, Seattle, WA, USA

Anjali S. Kumar, MD, MPH, FACS, FASCRS Department of Medical Education and Clinical Sciences, Elson S. Floyd College of Medicine, Washington State University, Everett, Spokane, Tri-Cities, Vancouver, WA, USA

Alex Jenny Ky, MD, FACS Mount Sinai School of Medicine, New York, NY, USA

Frederick R. Lane, MD Kendrick Colon and Rectal Center, Franciscan St. Francis Health, Indianapolis, IN, USA

Erin O. Lange, MD, MSPH Department of Surgery, University of Washington Medical Center, Seattle, WA, USA

Sang W. Lee, MD, FACS, FASCRS University of Southern California, Los Angeles, CA, USA

Martin Luchtefeld, MD, FACS, FASCRS Department of Colon and Rectal Surgery, Spectrum Health/Ferguson Clinic, Grand Rapids, MI, USA

Kim C. Lu, MD, FACS, FASCRS Division of Gastrointestinal and General Surgery, Department of Surgery, Oregon Health & Science University, Portland, OR, USA

Anthony R. MacLean, MD, FRCSC, FACS Department of Surgery, Foothills Medical Centre, University of Calgary, Calgary, AB, Canada

Helen M. MacRae, MD, MA, FRCSC, FACS Department of Surgery, Mount Sinai Hospital, Toronto, ON, Canada

Najjia N. Mahmoud, MD Division of Colon and Rectal Surgery, Department of Surgery, University of Pennsylvania Health System, Philadelphia, PA, USA

Christopher R. Mantyh, MD Department of Surgery, Duke University Medical Center, Durham, NC, USA

Jorge Marcet, MD Department of Surgery, Tampa General Hospital, Tampa, FL, USA

David J. Maron, MD, MBA Department of Colorectal Surgery, Cleveland Clinic Florida, Weston, FL, USA

Dipen C. Maun, MD Kendrick Colon and Rectal Center, Franciscan St. Francis Health, Indianapolis, IN, USA

Justin A. Maykel, MD Division of Colon and Rectal Surgery, University of Massachusetts Memorial Medical Center, Worcester, MA, USA

Michael F. McGee, MD, FACS, FASCRS Section of Colon and Rectal Surgery, Division of Gastrointestinal and Oncologic Surgery, Department of Surgery, Northwestern Memorial Hospital, Chicago, IL, USA

M. Shane McNevin, MD, FACS, FASCRS Sacred Heart Hospital, Spokane, WA, USA

Genevieve B. Melton, MD, PhD Division of Colon & Rectal Surgery, Department of Surgery, University of Minnesota Medical Center, Minneapolis, MN, USA

John Migaly, MD, FACS, FASCRS Division of Advanced GI & Oncologic Surgery, Duke University Medical Center, Durham, NC, USA

Steven Mills, MD Department of Surgery, University of California, Irvine, Orange, CA, USA

Husein Moloo, MD, MSc, FRCS Department of Surgery, Ottawa Hospital Research Institute, University of Ottawa, Ottawa, ON, Canada

Roberta Muldoon, MD Department of Surgery, Vanderbilt University Hospital, Nashville, TN, USA

Matthew G. Mutch, MD, FACS, FASCRS Section of Colon and Rectal Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Garrett M. Nash, MD, MPH Department of Surgery, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Guy R. Orangio, MD, FACS, FASCRS LSU Department of Surgery: Chief Section of Colon and Rectal Surgery, University Medical Center New Orleans, New Orleans, LA, USA

Emmanouil P. Pappou, MD, PhD Department of Colorectal Surgery, Columbia University, New York, NY, USA

Ian M. Paquette, MD Department of Surgery, Division of Colon and Rectal Surgery, University of Cincinnati Medical Center, Cincinnati, OH, USA

Marie Fidela R. Paraiso, MD Department of Obstetrics and Gynecology, Cleveland Clinic, Cleveland, OH, USA

W. Brian Perry, MD, FACS, FASCRS Audie L. Murphy VA Medical Center, San Antonio, TX, USA

Matthew M. Philp, MD, FACS, FASCRS Division of Colon and Rectal Surgery, Temple University Hospital, Philadelphia, PA, USA

Vitaliy Y. Poylin, MD, FACS, FASCRS Division of Colon and Rectal Surgery, Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Isabelle Raîche, MD, FRCS Department of Surgery, The Ottawa Hospital, University of Ottawa, Ottawa, ON, Canada

Jan Rakinic, MD, FACS, FASCRS Section of Colorectal Surgery, Department of Surgery, Southern Illinois University, Springfield, IL, USA

Thomas E. Read, MD, FACS, FASCRS Division of Gastrointestinal Surgery, University of Florida College of Medicine, Gainesville, FL, USA

Scott E. Regenbogen, MD, MPH Division of Colorectal Surgery, University of Michigan, Ann Arbor, MI, USA

Rocco Ricciardi, MD, MPH Massachusetts General Hosptal, Boston, MA, USA

Howard M. Ross, MD, FACS, FASCRS Department of Surgery, Division of Colon and Rectal Surgery, Temple University Hospital, Philadelphia, PA, USA

Andrew Russ, MD Department of Surgery, University Colon and Rectal Surgery, University of Tennessee Medical Center, Knoxville, TN, USA

Tushar Samdani, MD, MS, DNB(Surgery), MRCS(Edin) Department of Colorectal Surgery, Medstar Saint Mary's Hospital, Leonardo Town, MD, USA

Dana R. Sands, MD, FACS, FASCRS Department of Colorectal Surgery, Cleveland Clinic Florida, Weston, FL, USA

Giulio A. Santoro, MD, PhD Treviso Regional Hospital Italy, Treviso, Italy

Stephen M. Sentovich, MD, MBA Department of Surgical Oncology, City of Hope, Duarte, CA, USA

Matthew L. Silviera, MD Division of General Surgery, Section of Colon and Rectal Surgery, Department of Surgery, Barnes Jewish Hospital, Washington University School of Medicine, St. Louis, MO, USA

Michael J. Snyder, MD, FACS, FASCRS Department of Surgery, University of Texas Health Science, Houston, TX, USA

Mattias Soop, MD, PhD Department of Surgery, Salford Royal NHS Foundation Trust, Salford, UK

Manchester Academic Health Science Center, The University of Manchester, Manchester, UK

Constantine P. Spanos, MD, FACS, FASCRS Department of Colorectal Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

Department of Surgery, Aristotelian University of Thessaloniki, Panorama-Thessaloniki, Greece

Scott R. Steele, MD, MBA, FACS, FASCRS Department of Colorectal Surgery, Cleveland Clinic, Cleveland, OH, USA

David B. Stewart, Sr., MD, FACS, FASCRS Section Chief, Colorectal Surgery, University of Arizona - Banner University Medical Center, Tucson, AZ, USA

Scott A. Strong, MD, FACS, FASCRS Division of GI and Oncologic Surgery, Northwestern Medicine, Chicago, IL, USA

Daniel H. Teitelbaum, MD Section of Pediatric Surgery, University of Michigan C.S. Mott Children's Hospital, Ann Arbor, MI, USA

Amy J. Thorsen, MD University of Minnesota, Minneapolis, MN, USA

Konstantin Umanskiy, MD, FACS, FASCRS Department of Surgery, University of Chicago, Chicago, IL, USA

Cecile A. Unger, MD, MPH Department of Obstetrics and Gynecology, Cleveland Clinic, Cleveland, OH, USA

Michael A. Valente, DO, FACS, FASCRS Department of Colorectal Surgery, Digestive Disease Institute, Cleveland Clinic, Cleveland, OH, USA

H. David Vargas, MD, FACS, FASCRS Department of Colon and Rectal Surgery, Ochsner Medical Center, New Orleans, LA, USA

Madhulika K. Varma, MD Division of Colon and Rectal Surgery, University of California-San Francisco, San Francisco, CA, USA

Martin R. Weiser, MD Department of Surgery, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Mark L. Welton, MD, MHCM Corporate Department, Fairview Health Services, Minneapolis, MN, USA

Mark H. Whiteford, MD, FACS, FASCRS Providence Portland Medical Center, Providence Cancer Center, Portland, OR, USA

The Oregon Clinic, Gastrointestinal and Minimally Invasive Surgery, Portland, OR, USA

Oregon Health & Science University, Portland, OR, USA

Charles B. Whitlow, MD Department of Colon and Rectal Surgery, Ochsner Medical Center, New Orleans, LA, USA

Elizabeth C. Wick, MD Division of General Surgery, University of California San Francisco, San Francisco, CA, USA

Kirsten Bass Wilkins, MD, FACS, FASCRS Department of Surgery, RWJ Barnabas Health, Edison, NY, USA

Y. Nancy You, MD, MHSc Department of Surgical Oncology, University of Texas MD Anderson Cancer Center, Houston, TX, USA

Massarat Zutshi, MD Department of Colorectal Surgery, Lerner College of Medicine, Cleveland Clinic, Cleveland, OH, USA

Part I

Perioperative/ Endoscopy

1 Anatomy and Embryology of the Colon, Rectum, and Anus

Joseph C. Carmichael and Steven Mills

Key Concepts

- The dentate line represents a true division between embryonic endoderm and ectoderm.
- The location of the anterior peritoneal reflection is highly variable and can be significantly altered by disease such as rectal prolapse.
- The right and left ischioanal space communicate posteriorly through the deep postanal space between the levator ani muscle and anococcygeal ligament.
- The junction between the midgut (superior mesenteric artery) and the hindgut (inferior mesenteric artery) leads to a potential watershed area in the area of the splenic flexure.
- There is a normal, three-stage process by which the intestinal tract rotates during development beginning with herniation of the midgut followed by return of the midgut to the abdominal cavity and ending with its fixation.

Anatomy of the Anal Canal and Pelvic Floor

- The "anatomic" anal canal begins at the dentate line and extends to the anal verge.
- The "surgical" anal canal extends from the anorectal ring to the anal verge.
- The surgical anal canal is formed by the internal anal sphincter (IAS), external anal sphincter (EAS), and puborectalis (Fig. 1.1).
- The surgical anal canal is longer in males than in females. It averages 4.4 cm in males and 4.0 cm in females. Its length does not change with age.
- MR imaging shows that the anterior and posterior external anal sphincter length (not including puborectalis) was significantly shorter in women.
- The anal canal forms proximally where the rectum passes through the pelvic hiatus and joins with the puborectalis muscle and be thought of as a "tube within a tube."
- The inner tube is the visceral smooth muscle of the IAS and longitudinal layer that is innervated by the autonomic nervous system.
- The outer muscular tube consists of somatic muscles including the components of the puborectalis and EAS and is responsible for voluntary control.
- The EAS extends distal to the IAS, and the anal canal terminates at the anal verge where the superficial and subcutaneous portions of the external anal sphincter join the dermis.

J. C. Carmichael (✉) · S. Mills
Department of Surgery, University of California, Irvine, Orange, CA, USA
e-mail: jcarmich@uci.edu

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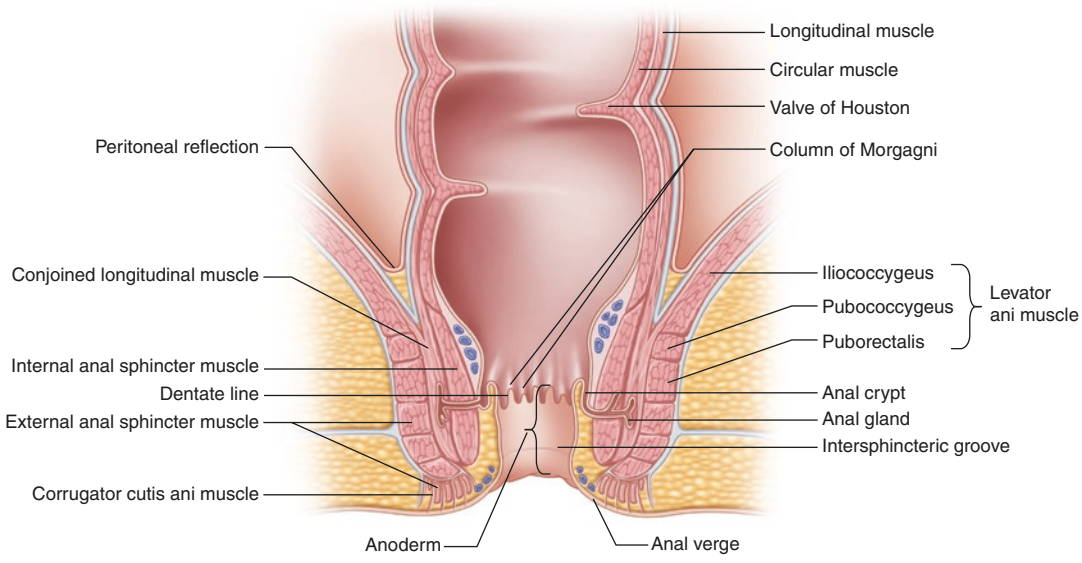

Fig. 1.1 Anal canal

Anal Canal Epithelium

- The proximal anal canal is lined by the columnar epithelium of the rectal mucosa.
- Six to twelve millimeter proximal to the dentate line, the anal transition zone (ATZ) begins, which is an area of gradual transition of columnar epithelium to squamous epithelium.
- The columns of Morgagni are redundant columns of tissue with anal crypts at their base. This forms the rippled dentate line (or pectinate line) which can be most easily identified – anal crypts are connected to underlying anal glands which are the presumed source of sepsis in the majority of anorectal abscesses and fistula. On average, there are six anal glands surrounding the anal canal (range 3–12) that are more concentrated in the posterior quadrants.
- All glands have a crypt but not all crypts have a gland. Some crypts are connected to multiple glands. The anal gland ducts proceed inferior and lateral from the anal canal and enter the submucosa where two-thirds enter the internal anal sphincter and half terminate in the intersphincteric plane.
- Distal to the dentate line, the anoderm begins and extends for approximately 1.5 cm. Anoderm has squamous histology and is devoid of hair, sebaceous glands, and sweat glands. At the anal verge, the anal canal lining becomes thickened and pigmented and contains hair follicles – this represents normal skin.
- The dentate line represents a true division between embryonic endoderm and ectoderm. Proximal to the dentate line, the innervation is via the sympathetic and parasympathetic systems, with venous, arterial, and lymphatic drainage associated with the hypogastric vessels. Distal to the dentate line, the innervation is via somatic nerves with blood supply and drainage from the inferior hemorrhoidal system.

Internal Anal Sphincter

- The internal anal sphincter is the downward continuation of the circular smooth muscle of the rectum. It terminates approximately 1 cm proximal to the distal aspect of the external anal sphincter producing a palpable

intersphincteric groove on physical exam. Imaging studies show that the IAS is approximately 2 mm in thickness and 35 mm in length on average.

Conjoined Longitudinal Muscle

- The anatomy and function of the perianal connective tissue plays a significant role in normal anorectal function. The conjoined longitudinal muscle (or conjoined longitudinal coat) lies in between the internal and external anal sphincters. It begins at the anorectal ring as an extension of the longitudinal rectal muscle fibers and descends caudally joined by fibers of the puborectalis muscle.
- At its most caudal aspect, some of the conjoined longitudinal muscle fibers (referred to as *corrugator cutis ani muscle*) traverse the distal external anal sphincter and insert into the perianal skin, and some enter the fat of the ischiorectal fossa. Some fibers of the conjoined longitudinal muscle interlace in a network within the subepithelial space and have been referred to as Treitz's muscle. They have also been referred to *corrugator cutis ani*, *musculus submucosae ani*, *mucosal suspensory ligament*, and *musculus canalis ani*.
- Possible functions of the conjoined longitudinal muscle include attaching the anorectum to the pelvis and acting as a skeleton that supports and binds the internal and external sphincter complex together.

External Anal Sphincter

- The external anal sphincter (EAS) is composed of striated muscle that forms an elliptical tube around the internal anal sphincter and conjoined longitudinal muscle.
- Goligher demonstrated that the external anal sphincter was truly a continuous sheet of skeletal muscle extending up to the puborectalis and levator ani muscles. While the external anal sphincter does not have three distinct anatomic layers, it is not uncommon to see the proximal portion of the EAS referred to as deep EAS, the midportion referred to as the superficial EAS, and the most distal aspect as the subcutaneous EAS.
- The mid-EAS has posterior attachment to the coccyx via the anococcygeal ligament, and the proximal EAS becomes continuous with the puborectalis muscle. Anteriorly, the proximal EAS forms a portion of the perineal body with the transverse perineal muscle.
- There are gender differences in the morphology of the anterior external anal sphincter that have been demonstrated on imaging. The normal female external anal sphincter has a variable natural defect (in 75% of nulliparous women) occurring along its proximal anterior length below the level of the puborectalis sling. Knowledge of this is important in interpreting anal ultrasound for fecal incontinence.
- The external anal sphincter is innervated on each side by the inferior rectal branch of the pudendal nerve (S2 and S3) and by the perineal branch of S4. There is substantial overlap in the pudendal innervation of the external anal sphincter muscle on the two sides which enables reinnervation to be partially accomplished from the contralateral side following nerve injury.

Perineal Body

- The perineal body represents the intersection of the external anal sphincter, superficial transverse perinei, deep transverse perinei, and bulbospongiosus (also referred to as bulbocavernosus) muscles (Fig. 1.2). Recent research suggests that the transverse perinei (TP) and bulbospongiosus (BS) muscles contribute significantly to anal incontinence. It has been proposed that the EAS, TP, and BS muscles be collectively referred to as the "EAS complex muscles."

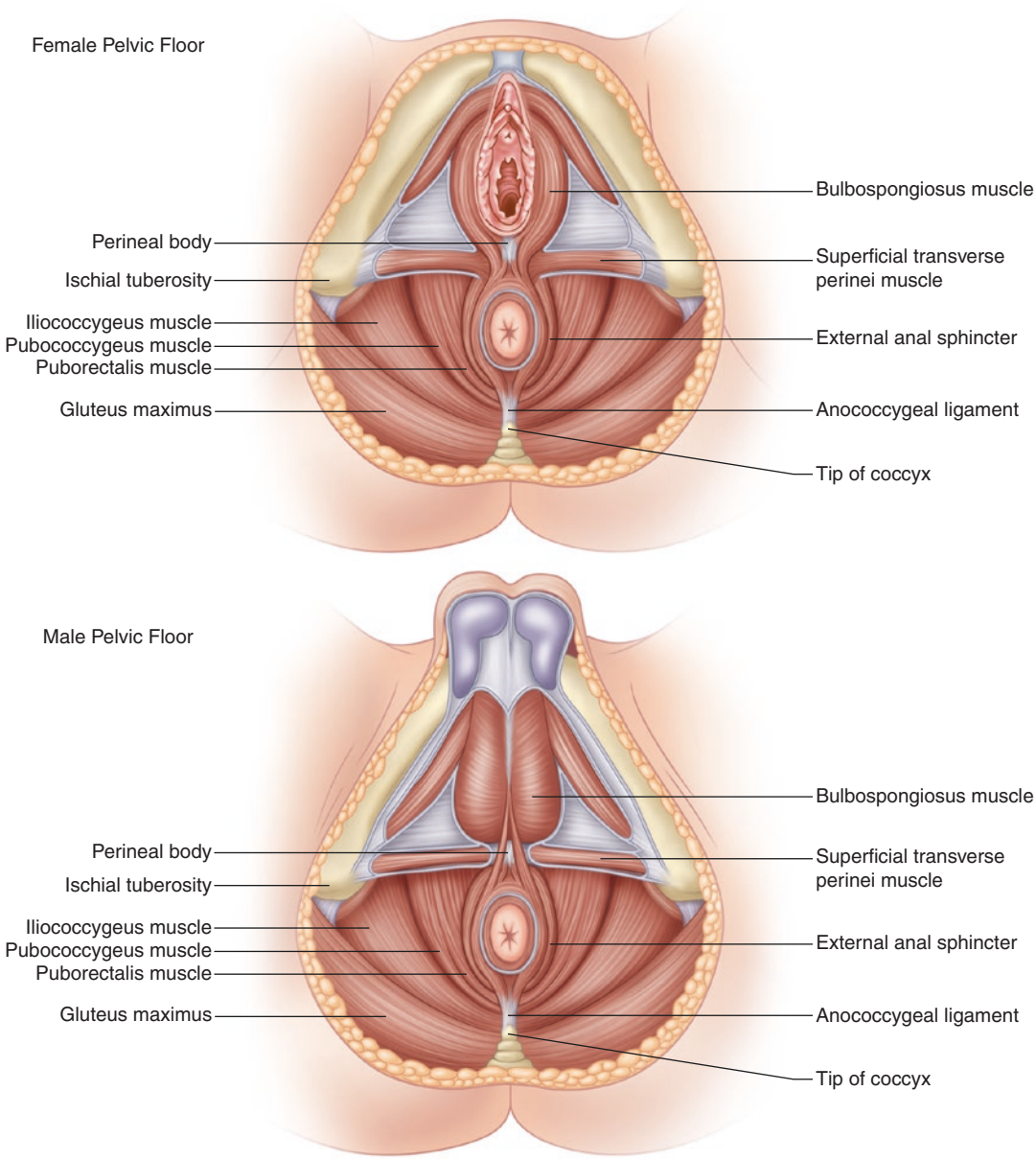

Fig. 1.2 Pelvic floor muscles

Pelvic Floor Muscles

- In addition to the anal sphincter and perineal body, the levator ani (LA) muscles contribute to pelvic organ support.
- The LA has three subdivisions including the pubococcygeus (aka pubovisceral), puborectalis, and iliococcygeus.
- In vivo MRI measurements in women have shown distinct, visible muscle fascicle directions for each of the three LA component muscles. Embryology studies have also demonstrated that the puborectalis muscle is a portion of the LA muscle and shares a common primordium with the iliococcygeus and pubococcygeus muscles.

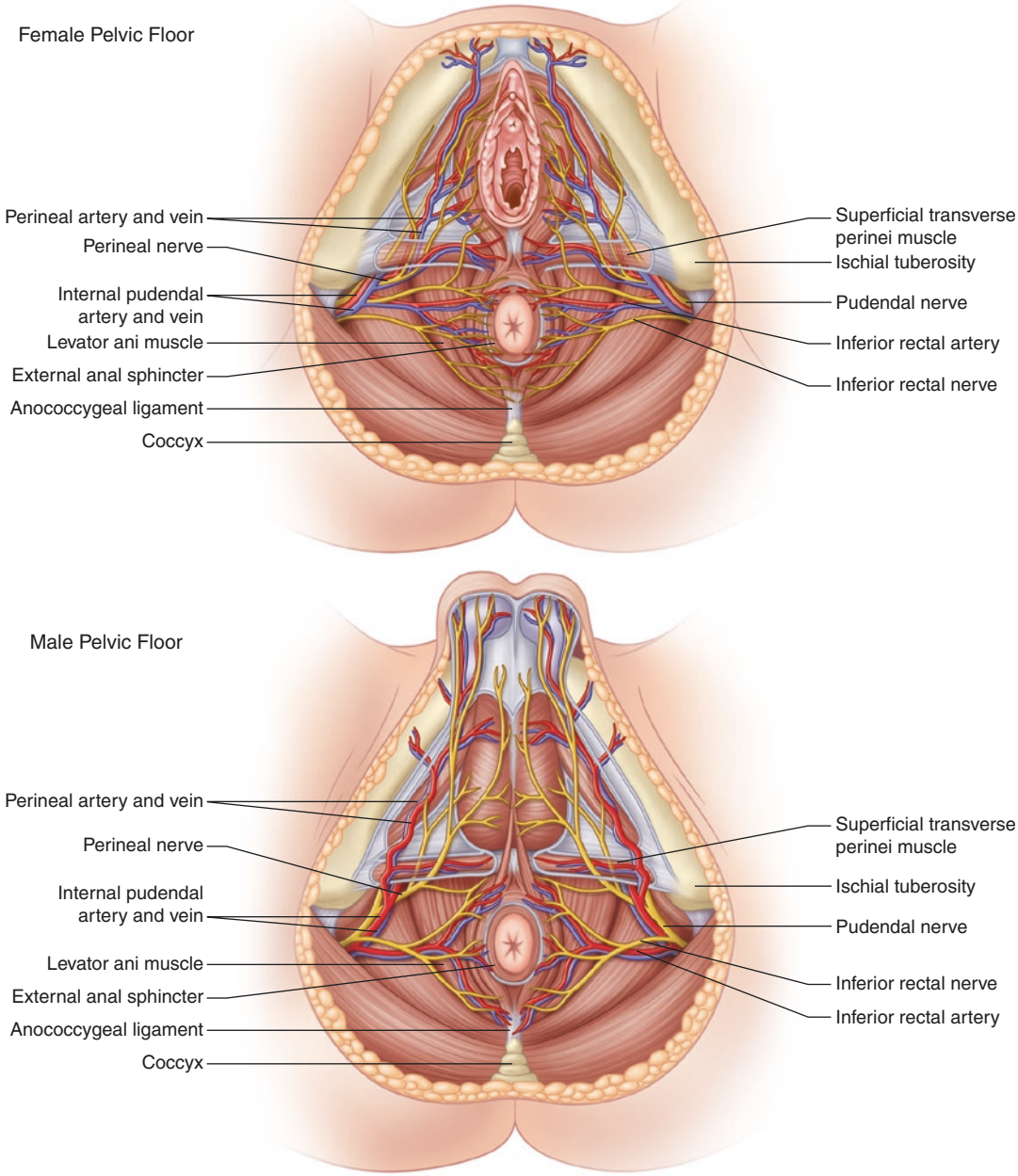

Fig. 1.3 Pelvic floor nerves and blood supply

- Contemporary cadaveric studies suggest that the LA muscles are innervated by the pudendal nerve branches: perineal nerve and inferior rectal nerve as well as direct sacral nerves S3 and/or S4 (i.e., levator ani nerve). The pubococcygeus muscle and puborectalis muscle are primarily innervated by the pudendal nerve branches, while the iliococcygeus muscle is primarily innervated by the direct sacral nerves S3 and/or S4 (Fig. 1.3).

Puborectalis Muscle

- The puborectalis muscle (PRM) fibers arise from the lower part of the symphysis pubis and from the superior fascia of the urogenital diaphragm and run alongside the anorectal junction. Posterior to the rectum, the fibers join forming a sling. The "anorectal ring" is composed of the upper borders of the internal anal sphincter and puborectalis muscle. Contraction of the PRM sling causes a horizontal force that closes the pelvic diaphragm and decreases the anorectal angle during squeeze. This is widely considered the most important contributing factor to gross fecal continence.

Iliococcygeus Muscle

- Iliococcygeus muscle (ICM) fibers arise from the ischial spines and posterior obturator fascia, pass inferior/posterior and medially, and insert into the distal sacrum, coccyx, and anococcygeal raphe. The ICM, along with the pubococcygeus muscle, contributes to "lifting" of the pelvic floor.

Pubococcygeus Muscle

- The pubococcygeus muscle (PCM) lies medial to the PRM. PCM fibers arise from the anterior half of the obturator fascia and the high posterior pubis. The PCM fibers intersect with fibers from the opposite side and form the anococcygeal raphe (or anococcygeal ligament). PCM fibers insert in the distal sacrum and tip of the coccyx, and portions contribute to the conjoined longitudinal muscle. The PCM forms the "levator hiatus" as it ellipses the lower rectum, urethra, and either the vagina in women or the dorsal vein of the penis in men. The levator hiatus is connected to the intrahiatal organs by a fascial condensation called the "hiatal ligament" (Fig. 1.4). The hiatal ligament arises circumferentially around the hiatal margin as a continuation of the fascia on the pelvic surface of the levator muscle. Enlargement of the levator hiatus has been implicated as a cause of female pelvic organ prolapse.

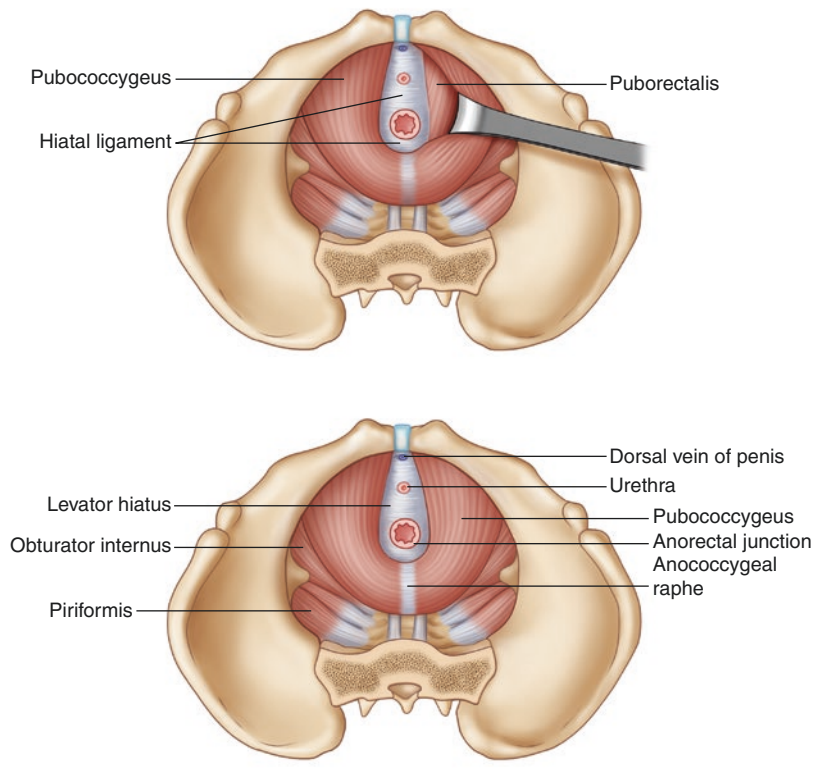

Fig. 1.4 Pelvic floor anatomy, abdominal view

Anatomy of the Rectum

- The rectum is of variable length but is commonly described as the upper (12–15 cm), middle (7–12 cm), and lower (0–<7 cm) rectum. While not anatomically distinct, the divisions are important when considering surgical treatment of rectal cancer. The upper rectum can be distinguished from the sigmoid colon by the absence of taenia coli and epiploic appendages.
- The majority of the rectum is extraperitoneal. Anteriorly and laterally the upper rectum is covered by a layer of visceral peritoneum down to the peritoneal reflection. The location of the anterior peritoneal reflection is highly variable but on average is 9 cm from the anal verge in females and 9.7 cm in males.

Mesorectum

- In anatomic terms, the prefix "meso" refers to two layers of peritoneum that suspend an organ, and the suffix applied indicates the target organ (e.g., mesocolon). Therefore the term mesorectum is a misnomer except in patients with a mobile suspended rectum as can be seen in rectal prolapse.
- The mesorectum is a term employed by surgeons to describe the fascial envelope of the rectum that is excised during surgical treatment of rectal cancer. Indeed, failure to completely excise this envelope intact has been associated with an increased incidence of local recurrence of rectal cancer. The mesorectum is contained within the fascia propria. The fascia propria is an upward projection of the parietal endopelvic fascia that lines the walls and floor of the pelvis. The fascia propria encloses the perirectal fat, lymphatics, blood vessels, and nerves.

Presacral Fascia

- The presacral fascia is a thickened portion of the parietal endopelvic fascia overlying the sacrum that covers the presacral veins and hypogastric nerves (Fig. 1.5). It extends laterally to cover the

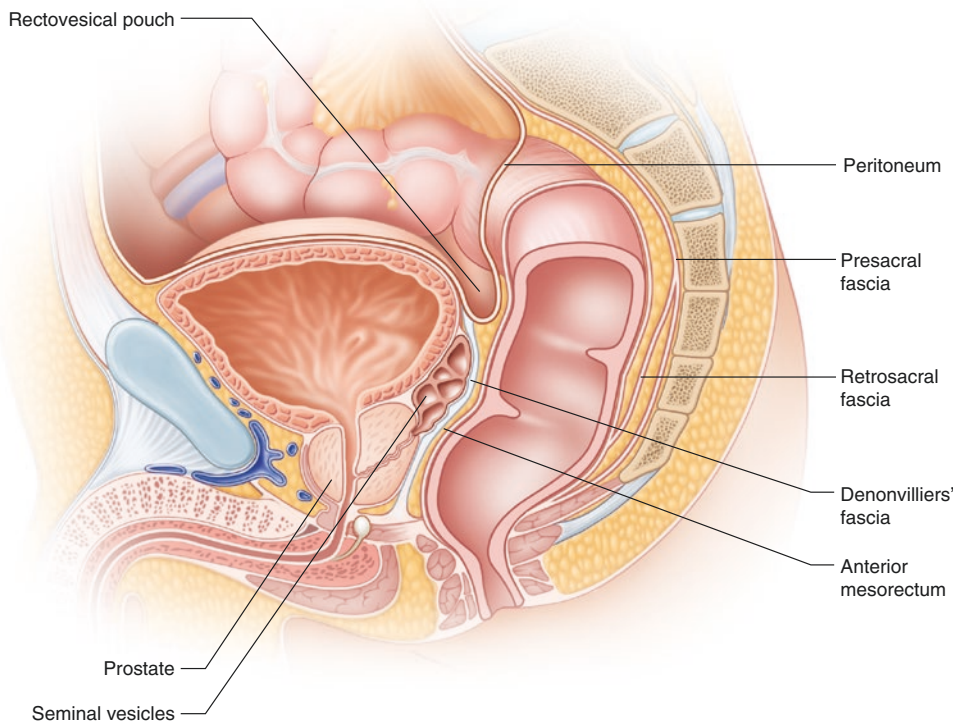

Fig. 1.5 Fascial relationships of the rectum

piriformis and upper coccyx. As the presacral fascia extends laterally, it becomes continuous with the fascia propria and contributes to the lateral ligaments of the rectum. Caudally, this fascia extends to the anorectal junction covering the anococcygeal ligament. During total mesorectal excision, the fascia propria is elevated sharply off the presacral fascia. Leaving the presacral fascia intact eliminates the possibility of causing substantial presacral bleeding.

Retrosacral Fascia

- The retrosacral fascia originates at the third and fourth portion of the sacrum and extends anteriorly to the posterior layer of the fascia propria 3–5 cm proximal to the anorectal junction. This tough fascia layer is surgically relevant as it must be sharply incised during total mesorectal excision. The space posterior to the retrosacral fascia is referred to as the supralevator or retrorectal space.

Waldeyer's Fascia

- There is significant confusion about what Waldeyer's fascia represents as the eponym has been used to describe the presacral fascia, the rectosacral fascia, or all fascia posterior to the rectum. In Waldeyer's original description of pelvic fascia, there was no particular emphasis on the presacral component. While the debate continues regarding "Waldeyer's fascia," it is important to simply understand that the phrase can have the potential to mean presacral fascia, retrosacral, or retrorectal fascia.

Denonvilliers' Fascia

- Denonvilliers' fascia arises from the fusion of the two walls of the embryological peritoneal cul-de-sac and extends from the deepest point of the rectovesical pouch to the pelvic floor. It was originally described by Denonvilliers in 1836 as a "prostatoperitoneal" membranous layer between the rectum and seminal vesicles.
- Denonvilliers' fascia is also present in females as part of the rectovaginal septum and is sometimes referred to as rectovaginal fascia. It is found immediately beneath the vaginal mucosa and is clearly what most would consider as part of the vaginal wall. It merges superiorly with the cardinal/uterosacral complex in females or the rectovesical pouch in males. It merges laterally with the endopelvic fascia overlying the levator muscle and distally with the perineal body. It contains collagen and some strands of smooth muscle and heavy elastin fibers.
- Microscopically, Denonvilliers' fascia has two layers, but they are not grossly discernable. In the anterior rectal plane, the mesorectum is contained by the fascia propria which lies dorsal to Denonvilliers' fascia.
- The cavernous nerves run in neurovascular bundles at the anterolateral border of Denonvilliers' fascia.

Lateral Ligaments

- There are two controversial points regarding the lateral ligaments of the rectum. Do the lateral ligaments exist? What do they contain?
- In his seminal description of abdominoperineal resection in 1908, William Ernest Miles refers to division of the lateral ligaments of the rectum.
- One modern cadaveric dissection study identified the presence of a middle rectal artery in only 22% of specimens.
- Total mesorectal excision, as popularized and described by Heald, involves sharp dissection along the fascia propria circumferentially to the pelvic floor. While acknowledging that the middle rectal vessels are "divided as far from the carcinoma as possible," Heald does not mention "lateral ligaments" of the rectum at all.
- One review of the anatomy of the lateral ligament states that it is a common misconception

that the lateral ligaments contain the middle rectal artery. It appears that the lateral ligaments comprise "primarily nerves and connective tissue" and their division without bleeding attests to the absence of a "significant accessory rectal artery in this location in the majority of patients."

- In another cadaveric study, the lateral ligaments of the rectum were identified as trapezoid structures originating from mesorectum and anchored to the endopelvic fascia at the level of the midrectum. It was recommended that, as lateral extensions of the mesorectum, the ligaments must be cut and included in the total mesorectal excision (TME) specimen. It was further noted that the lateral ligaments did not contain middle rectal arteries or nerve structures of importance. Other modern cadaveric investigations note the rarity of middle rectal arteries and the absence of clinically relevant neurovascular structures in the lateral ligaments.

Valves of Houston

- The rectum has been classically described to have three distinct, semicircular, inner folds called valves of Houston (Fig. 1.1) with the superior and inferior valves located on the left side of the rectum and the more prominent middle rectal valve on the right.
- Anatomic variation is common, with only 45.5% of patients having the classic "three valve anatomy"; 32.5% will have only two valves, and 10.25% will have four valves.

Anorectal Spaces

- Several anorectal spaces are created by the various myofascial relationships in the pelvis. They are important in understanding how anorectal sepsis can spread throughout the pelvis.

Perianal Space

- The perianal space contains external hemorrhoid cushions, the subcutaneous external anal sphincter, and the distal internal anal sphincter. The perianal space is in communication with the intersphincteric space (Fig. 1.6). Its cephalad boundary is the dentate line, and its lateral boundaries are the subcutaneous fat of the buttocks. It is contained by fibers extending from the conjoined longitudinal muscle often referred to as *corrugator cutis ani* muscle fibers. Otherwise, the perianal space is contained by anoderm.

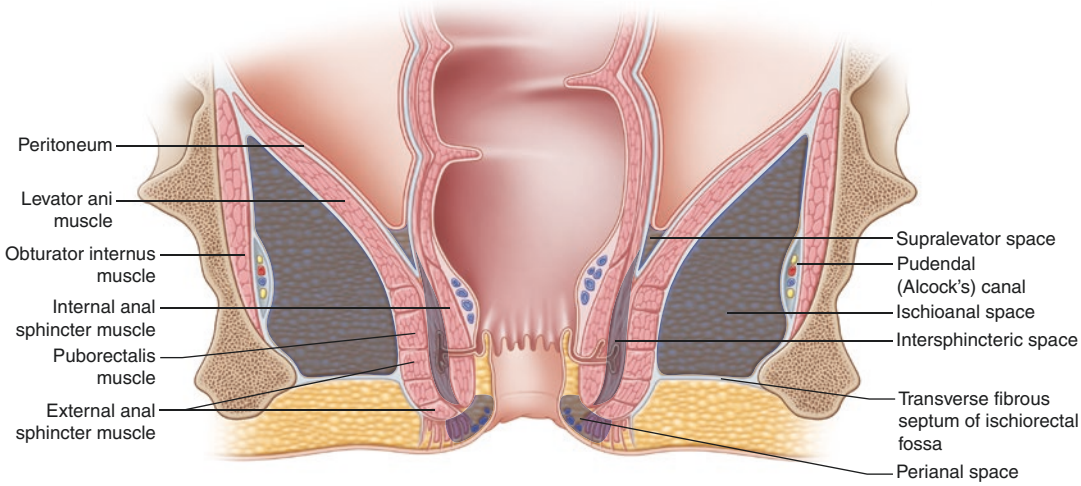

Fig. 1.6 Perianal and perirectal spaces, coronal view

Intersphincteric Space

- The intersphincteric space is the potential space that lies between the internal and external anal sphincters and is continuous with the perianal space. It is of clinical importance as cryptoglandular infections tend to begin in this area and expand elsewhere to create anal fistulas.

Submucous Space

- This space lies between the medial border of the internal anal sphincter and the anal mucosa proximal to the dentate line. It is continuous with the submucosa of the rectum. This area contains internal hemorrhoid vascular cushions.

Ischioanal/Ischiorectal Space

- The ischioanal (also referred to as ischiorectal) space is the largest anorectal space. It has been described as a pyramid shape with its apex at the levator muscle insertion into the obturator fascia. Its borders are as follows:
  - Medial – the levator ani muscle and external anal sphincter
  - Lateral – obturator internus muscle and obturator fascia
  - Posterior – the lower border of the gluteus maximus muscle and the sacrotuberous ligament
  - Anterior – the superficial and deep transverse perineal muscles
  - Caudal – the skin of the perineum
- The ischioanal fossa contains the adipose tissue, pudendal nerve branches, and superficial branches of the internal pudendal vessels.
- The right and left ischioanal space communicate posteriorly through the deep postanal space between the levator ani muscle and anococcygeal ligament (Fig. 1.7). When the ischioanal and perianal spaces are regarded as a single space, it is referred to as the ischioanal fossa.

Supralevator Space

- The upper boundary of the supralevator space is the peritoneum, the lateral boundary is the pelvic wall, the medial boundary is the rectum, and the inferior boarder is the levator ani muscle (Fig. 1.8).

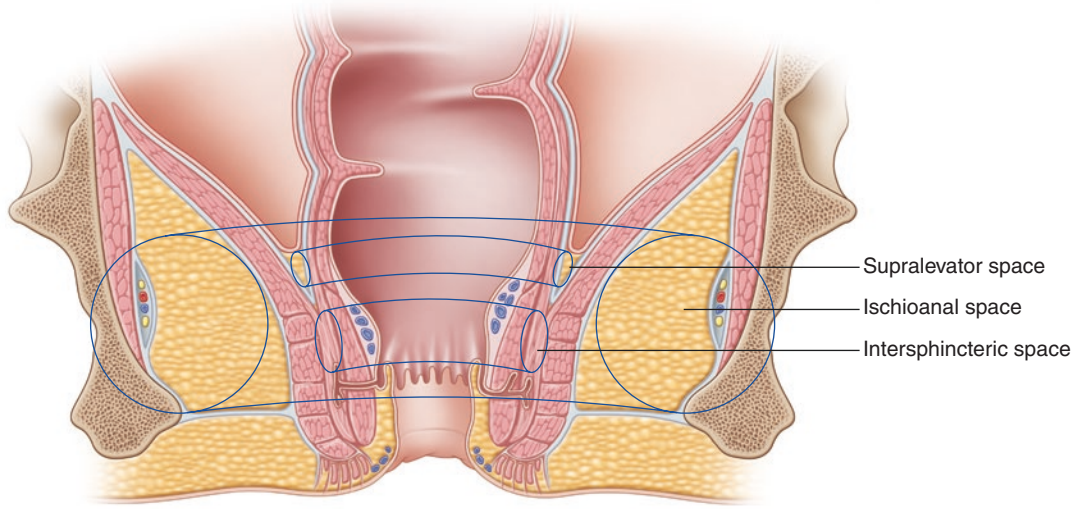

Fig. 1.7 Communication of the anorectal spaces