Yuri W. Novitsky
Editor

Hernia Surgery

Current Principles

EXTRAS ONLINE

Springer

Hernia Surgery

Yuri W. Novitsky
Editor

Hernia Surgery

Current Principles

Springer

Editor
Yuri W. Novitsky
Case Comprehensive Hernia Center
University Hospitals Case Medical Center
Cleveland, OH, USA

Videos can also be accessed at
http://link.springer.com/book/10.1007/978-3-319-27470-6

ISBN 978-3-319-27468-3 ISBN 978-3-319-27470-6 (eBook)
DOI 10.1007/978-3-319-27470-6

Library of Congress Control Number: 2016935505

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

"To Anusha—my remarkable mother, to Heidi—my wonderful wife, to Maya, Ella, Lily, and Phoebe—my amazing daughters. Everything is possible with your love and support."

Preface

Hernia repair remains one of the most common surgical procedures performed, but there is little consensus as to the best surgical technique, prosthetic material of choice, or most appropriate strategies to repair abdominal wall hernias. *Hernia Surgery: Current Principles* will serve as a state-of-the-art reference in the rapidly changing field of hernia surgery. With contributions by key opinion leaders in the field, this book will describe the latest trends and detailed technical nuances to approach both routine and complex of hernia scenarios. The reader will gain unique insights into a wide spectrum of hernia issues, including clinical anatomy and physiology of the abdominal wall, mesh selection, patient optimization, robotic and laparoscopic repairs, anterior and posterior component separations, parastomal, flank, suprapubic and other difficult hernia repairs, as well as reconstructions in the setting of contamination, enterocutaneous fistulas, and loss of abdominal domain. Furthermore, important issues in inguinal repairs, including open, laparoscopic and robotic repairs, postoperative groin pain, and treatment of sports hernias are extensively covered. Finally, important contributions from key reconstructive plastic surgeons will detail modern trends on how to deal with complex skin and soft tissue challenges, including concurrent panniculectomies, tissue expanders, and myofascial flaps. The textbook will provide unparalleled step-by-step instructions to perform both routine and complex repairs by using vivid illustrations and by highlighting operative details through intra-operative color photographs and a unique video collection of procedures performed and narrated by today's top hernia surgeons.

As a comprehensive and most up-to-date reference to modern trends in mesh science and technique selections, *Hernia Surgery: Current Principles* will be an invaluable resource to all residents and practicing general, plastic, and trauma surgeons to help them succeed in the field of Hernia surgery.

Cleveland, OH, USA — Yuri W. Novitsky

Contents

List of Videos

Contributors

Gina L. Adrales, M.D., M.P.H. Division of Minimally Invasive Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

Parviz K. Amid, M.D. Department of Surgery, Lichtenstein Amid Hernia Clinic at UCLA, Santa Monica, CA, USA

Manuel Armengol-Carrasco, M.D., Ph.D. Department of Surgery, Hospital Universitari Vall d'Hebron, Barcelona, Spain

Vedra A. Augenstein, M.D. Division of Gastrointestinal and Minimally Invasive Surgery, Department of Surgery, Carolinas Medical Center, Charlotte, NC, USA

Conrad Ballecer, B.S., M.S., M.D. Arrowhead Medical Center, Banner Thunderbird Medical Center, Peoria, AZ, USA

Donald P. Baumann, M.D. Department of Plastic Surgery, University of Texas MD Anderson Cancer Center, Houston, TX, USA

Igor Belyansky, M.D. Department of Surgery, Anne Arundel Medical Center, Annapolis, MD, USA

Parag Bhanot, M.D. Department of Surgery, Medstar Georgetown University Hospital, Washington, DC, USA

Martin F. Bjurstrom, M.D. Department of Anesthesiology, Lichtenstein Amid Hernia Clinic at UCLA, Santa Monica, CA, USA

Terra R. Blatnik, M.D. Cleveland Clinic, Twinsburg, OH, USA

Jeffrey A. Blatnik, M.D. Department of Surgery, Section of Minimally Invasive Surgery, Washington University School of Medicine, St. Louis, MO, USA

L. Michael Brunt, M.D. Department of Surgery, Washington University School of Medicine, Saint Louis, MO, USA

Charles E. Butler, M.D. Department of Plastic Surgery, University of Texas MD Anderson Cancer Center, Houston, TX, USA

Alfredo M. Carbonell, D.O. Division of Minimal Access and Bariatric Surgery, Greenville Health System, University of South Carolina School of Medicine, Greenville, SC, USA

Phillip Chang, M.D. Department of Surgery, University of Kentucky, Lexington, KY, USA

David C. Chen, M.D. Department of Surgery, Lichtenstein Amid Hernia Clinic at UCLA, Santa Monica, CA, USA

Lauren Chmielewski, M.D. Department of Plastic Surgery, University Hospitals Case Medical Center, Cleveland, OH, USA

Karan Chopra, M.D. Department of Plastic Surgery, University of Maryland School of Medicine, Johns Hopkins University, Baltimore, MD, USA

William S. Cobb IV , M.D. Department of Surgery, The Hernia Center, Greenville Health System, Greenville, SC, USA

Jorge D. Daes, M.D., F.A.C.S. Department of Minimally Invasive Surgery, Clinica Bautista, Barranquilla, Columbia

Eduardo Parra Davila, M.D. General/Colorectal Surgery, Celebration, FL, USA

Corey R. Deeken, Ph.D. Covalent Bio, LLC, Eureka, MO, USA

Clifford Deveney, M.D. Department of Surgery, Oregon Health & Science University, Portland, OR, USA

Christopher DuCoin, M.D., M.P.H. Department of Surgery, University of California, San Diego, La Jolla, CA, USA

Gregory A. Dumanian, M.D. Department of Plastic Surgery, Northwestern Memorial Hospital, Chicago, IL, USA

David Earle, M.D. Department of Surgery, Tufts University School of Medicine, Springfield, MA, USA

Karen K. Evans, M.D. Department of Plastic Surgery, Georgetown University Hospital, Washington, DC, USA

Erin M. Garvey, M.D. Division of General Surgery, Mayo Clinic Arizona, Phoenix, AZ, USA

Kristi L. Harold, M.D. Division of General Surgery, Mayo Clinic Arizona, Phoenix, AZ, USA

William Hope, M.D. Department of Surgery, New Hanover Regional Medical Center, Wilmington, NC, USA

Ciara R. Huntington, M.D. Department of Surgery, Carolinas Medical Center, Charlotte, NC, USA

Kamal M.F. Itani, M.D. Department of Surgery, VA Boston Health Care System and Boston University, West Roxbury, MA, USA

Brian P. Jacob, M.D. Department of Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, USA

Garth Jacobsen, M.D. University of California, San Diego, San Diego, CA, USA

An P. Jairam, M.D. Department of Surgery, Erasmus University Medical Center, Rotterdam, The Netherlands

Jeffrey E. Janis, M.D. Department of Plastic Surgery, University Hospital, Ohio State University Wexner Medical Center, Columbus, OH, USA

Ryan M. Juza, M.D. Department of Surgery, Penn State Milton S. Hershey Medical Center, Hershey, PA, USA

Kent W. Kercher, M.D. Division of Gastrointestinal and Minimally Invasive Surgery, Carolinas Medical Center, Charlotte, NC, USA

Tammy Kindel, M.D., Ph.D. Department of Surgery, University of Nebraska Medical Center, Omaha, NE, USA

David M. Krpata, M.D. General Surgery, Cleveland Clinic Comprehensive Hernia Center, Cleveland Clinic, Cleveland, OH, USA

Johan F. Lange, M.D., Ph.D. Department of Surgery, Erasmus University Medical Center, Rotterdam, The Netherlands

Melissa Phillips LaPinska, M.D. Department of Surgery, University of Tennessee Health Science Center, Knoxville, TN, USA

Hien Le, M.D. University of Tennessee Medical Center, Knoxville, TN, USA

Michelle Lee, M.D. Plastic and Reconstructive Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Austin Lewis, M.D. Department of Surgery, University of Tennessee Health Science Center, Knoxville, TN, USA

Manuel Lopez-Cano, M.D., Ph.D. Abdominal Wall Surgery Unit, Universitary Hospital Vall D'hebron, Universidad Autonoma De Barcelona, Barcelona, Spain

Albert Losken, M.D. Department of Plastic Surgery, Emory University Hospital, Atlanta, GA, USA

Ryan P. Ter Louw, M.D. Georgetown University Hospital, Washington, DC, USA

Arnab Majumder, M.D. Department of Surgery, University Hospitals Case Medical Center, Cleveland, OH, USA

Gregory J. Mancini, M.D. Department of Surgery, University of Tennessee Health Science Center, Knoxville, TN, USA

Robert G. Martindale, M.D., Ph.D. Division of General Surgery, Oregon Health & Science University, Portland, OR, USA

Issa Mirmehdi, M.D. Halifax Health, General Surgery, Daytona Beach, FL, USA

Maurice Y. Nahabedian, M.D. Department of Plastic Surgery, Georgetown University, Washington, DC, USA

Yuri W. Novitsky, M.D. Department of Surgery, University Hospitals Case Medical Center, Cleveland, OH, USA

Sean M. O'Neill, M.D., Ph.D. Department of Surgery, Lichtenstein Amid Hernia Clinic at UCLA, Santa Monica, CA, USA

Dmitry Oleynikov, M.D. Department of Surgery, University of Nebraska Medical Center, Omaha, NE, USA

Sean B. Orenstein, M.D. Division of Gastrointestinal and General Surgery, Oregon Health & Science University, Portland, OR, USA

Eric M. Pauli, M.D. Division of Minimally Invasive and Bariatric Surgery, Department of Surgery, Penn State Hershey Medical Center, Hershey, PA, USA

Clayton C. Petro, M.D. Department of General Surgery, Case Comprehensive Hernia Center, University Hospitals Case Medical Center, Cleveland, OH, USA

Richard A. Pierce, M.D., Ph.D. Department of Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

Benjamin K. Poulose, M.D., M.P.H. Department of Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

William F. Powers IV, M.D. Department of Surgery, New Hanover Regional Medical Center, Wilmington, NC, USA

Ajita Prabhu, M.D. Department of Surgery, University Hospitals Case Medical Center, Cleveland, OH, USA

Bruce Ramshaw, M.D. Department of Surgery, University of Tennessee Health Science Center, Knoxville, TN, USA

Gabrielle H. van Ramshorst, M.D., Ph.D. Department of Surgery, VU Medical Center, Erasmus University Medical Center, Amsterdam, The Netherlands

Sergio Roll, M.D., Ph.D. Department of Surgery, Santa Casa of Sao Paulo Hospital and Oswaldo Cruz German Hospital, Sao Paulo, Brazil

J. Scott Roth, M.D. Department of Surgery/General Surgery, A.B. Chandler Medical Center, University of Kentucky, Lexington, KY, USA

Michael G. Sarr, M.D. Department of Surgery, Mayo Clinic, Rochester, MN, USA

Sarah Sher, M.D. Department of Plastic Surgery, Georgetown University Hospital, Washington, DC, USA

C. Jeff Siegert, M.D. VA Boston Health care System, West Roxbury, MA, USA

Devinder Singh, M.D. Department of Surgery, Anne Arundel Medical Center, Annapolis, MD, USA

James Skinovsky, Ph.D. Positivo University, Curitiba, Curitiba, Paraná, Brazil; Department of Surgery, Red Cross University Hospital, Curitiba, Paraná, Brazil

Hooman Soltanian, M.D. Department of Plastic Surgery, Case Medical Center, Cleveland, OH, USA

Nathaniel Stoikes, M.D. Department of Surgery, University of Tennessee Health Science Center, Germantown, TN, USA

Peter W. Thompson, M.D. Plastic and Reconstructive Surgery, Emory University, Atlanta, GA, USA

Guy R. Voeller, M.D. Department of Surgery, University of Tennessee Health Science Center, Germantown, TN, USA

Thomas Wade, M.D. Department of Surgery, Washington University School of Medicine, St Louis, MO, USA

David Webb, M.D. Baptist Memphis and Methodist Germantown, Memphis, TN, USA

John E. Wennergren, M.D. Department of Surgery, University of Kentucky Chandler Hospital, Lexington, KY, USA

Matthew Z. Wilson, M.D. Department of Surgery, Section of Minimally Invasive Surgery, Washington University in St. Louis, St. Louis, MO, USA

Joshua S. Winder, M.D. Division of Minimally Invasive Surgery, Department of General Surgery, Penn State Milton S. Hershey Medical Center, Hershey, PA, USA

H. Reza Zahiri, D.O. Division of Minimally Invasive Surgery, Department of Surgery, Anne Arundel Medical Center, Annapolis, MD, USA

Terri A. Zomerlei, M.D. Department of Plastic Surgery, Wexner Medical Center, Ohio State University, Columbus, OH, USA

Clinical Anatomy and Physiology of the Abdominal Wall

1

Arnab Majumder

Introduction

The modern field of abdominal wall surgery relies on a thorough understanding of all components of the abdominal wall as well as their function and physiology. Advancements in technology have provided surgeons with a wide variety of mesh prosthetics along with novel tools to assist in hernia repair. As a result, improvements in recurrence rates and patient outcomes have been well documented [1, 2]. However, it is the steady progress in the understanding of the abdominal wall itself that has enabled the creation of more complex procedures including myofascial and musculocutaneous advancement flaps via component separation and muscle release [3–9]. Such advancements have allowed surgeons the technical ability to deploy prosthetics in novel manners and allow for closure of abdominal defects that were in the past considered impossible. Consequently, a comprehensive grasp of technical options should occur in tandem with a complete and systematic understanding of abdominal wall anatomy and physiology.

This chapter serves to provide a framework for understanding the clinical anatomy of the abdominal wall as well as the relevant physiology and critical relationships that arise during surgery. A fundamental grasp of surface and deep anatomy is assumed with focus given to more subtle clinical findings based on these foundations. The chapter is framed to emphasize the importance in restoration of the linea alba during these repairs.

A. Majumder, M.D. (✉)
Department of Surgery, University Hospitals Case Medical Center, 11100 Euclid Ave, Cleveland, OH 44106, USA
e-mail: arnab.majumder@uhhospitals.org

Boundaries

The anterior abdominal wall is a hexagonal area bounded by the xiphoid process superiorly with delineation of the superolateral edges by the costal margins. Inferiorly it extends along the iliac crests and narrows to the superior edge of the pubic bone of the pelvis in the midline. The inferolateral margins are defined by the inguinal ligaments bilaterally. Lateral extension occurs posteriorly to the erector spinae and quadratus lumborum muscles adjacent to the lumbar spine as these muscles contribute to the thoracolumbar fascia along with transversus abdominis [10] (Fig. 1.1).

The dynamic group of muscles contained in these boundaries is unique in that they are void of any bony structures aside from their attachments. However, given their broad area, the muscular groups serve a variety of purposes in coordination with other body systems. Integral roles include assistance with defecation and urination as well as respiration and coughing via an increase or decrease in intra-abdominal and intra-thoracic

Y.W. Novitsky (ed.), *Hernia Surgery*, DOI 10.1007/978-3-319-27470-6_1

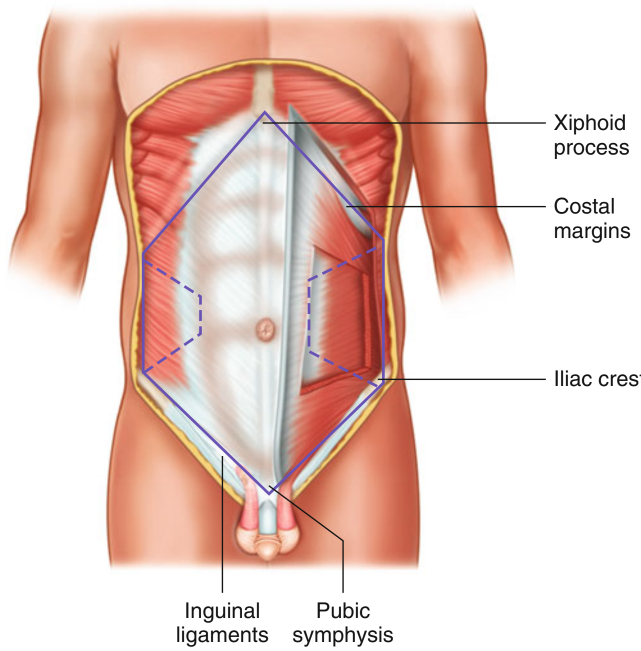

Fig. 1.1 Boundaries of the abdominal wall shown as a hexagonal area anteriorly with lateral extension around the flanks toward the muscles of the back

pressures. Additionally, in concert with muscles of the back the abdominal wall serves to flex, extend, and rotate the torso from the hips. Tension generated in the thoracolumbar fascia along with muscles of the back provides stabilization for the lumbosacral spine and pelvis, both playing a critical role in posture [11]. Finally, the robust overlap of the muscular girdle also provides physical protection for the underlying viscera when contracted. Given the large variety of roles of the abdominal wall, a critical understanding of each component and its function is paramount, with the ultimate goal of restoration or maintenance of these functions following surgery.

Components

The abdominal wall can be divided into midline and anterolateral groups of muscles comprising four main paired muscle groups and a variably present paired fifth muscle group. The muscular groups are covered by subcutaneous fat and skin along with superficial neurovascular structures which overlay the fascia. The rectus abdominis and the pyramidalis muscles comprise the midline group, although the presence of the pyramidalis is not consistent among the population [12, 13] (Fig. 1.2). The bilateral anterolateral groups are composed of a trilaminar structure consisting of the external oblique muscles (EOMs), internal oblique muscles (IOMs), and transversus abdominis muscles (TAMs) (Fig. 1.3). In addition to the muscular groups and their associated neurovascular supply, there are a number of key tendinous structures and delineations including the linea alba, linea semilunaris, linea semicircularis (arcuate line of Douglas) as well as the anatomic spaces of Retzius and Bogros, formed from the interaction of these muscle groups, that are equally as important to understand.

Linea Alba

While the muscular components of abdominal wall are of crucial importance, the restoration of linea alba remains the goal of definitive abdominal wall reconstruction. This chapter begins with attention given to this oft-overlooked, but ultimately vital structure.

Literally translated as *the white line*, the linea alba is a completely fibrous structure composed of collagen and elastin traversing from the

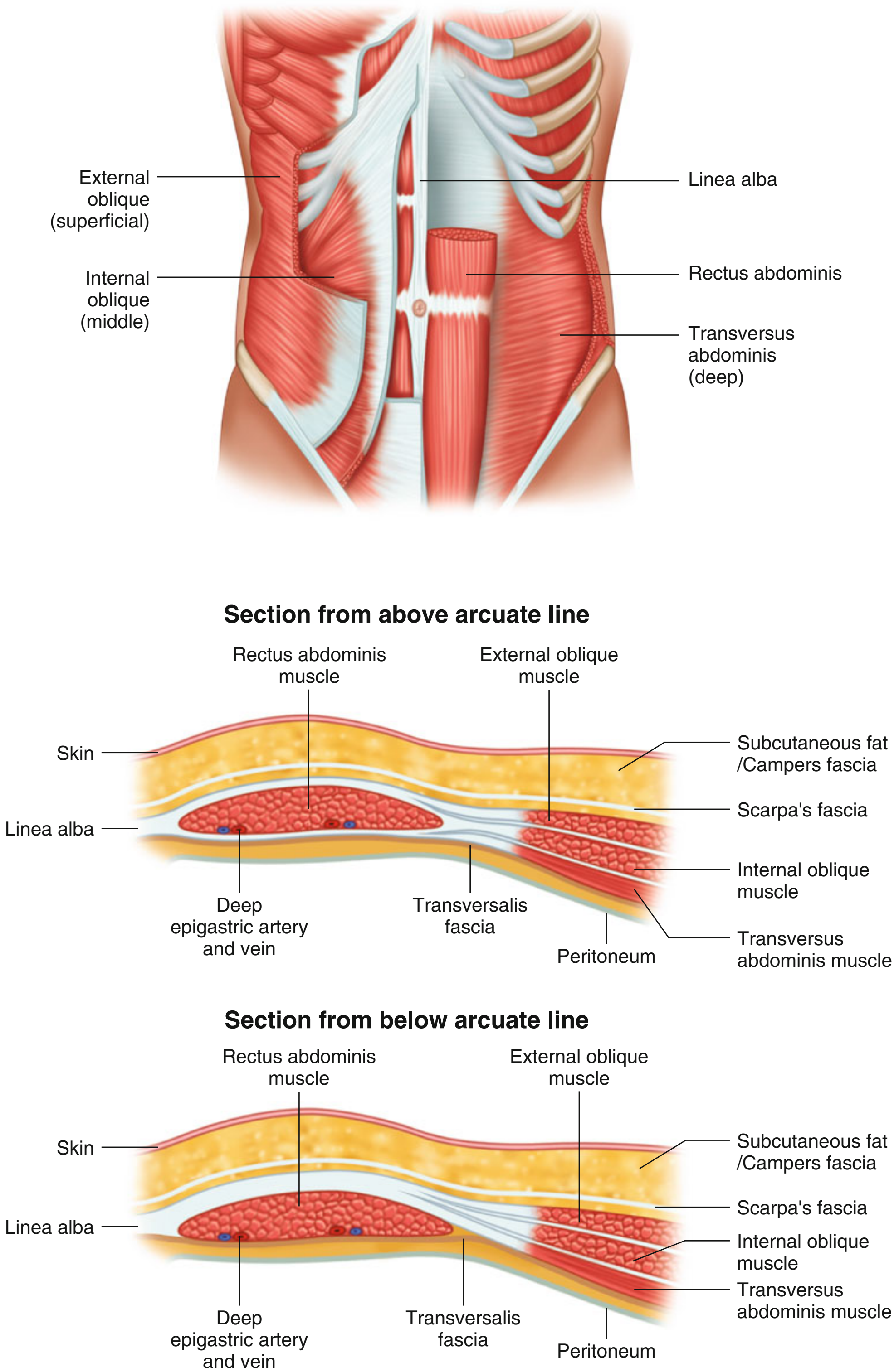

Fig. 1.2 Muscles of the abdominal wall with the anterolateral group comprising the external and internal oblique along with the transversus abdominis extending medial to the linea semilunaris. The midline group is comprised of the rectus abdominis and pyramidalis muscles. Cross sections are illustrated above and below the arcuate line

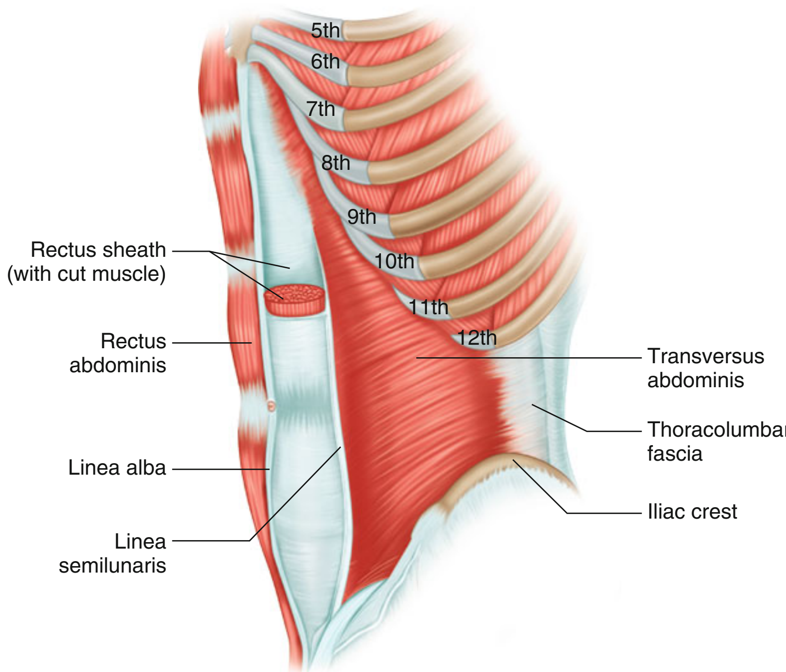

Fig. 1.3 Transversus abdominis shown with relation to the rectus sheath, notably the fibers extend medial to the linea semilunaris superiorly with a more aponeurotic component inferiorly

xiphoid process to the pubis symphysis. The linea alba varies in width among the population but generally is accepted as being approximately 15–22 mm along its course, widest at or just above the umbilicus and narrowing at superior and inferior extremes [14, 15]. It is formed as the aponeurosis of the EOMs, IOMs, and TAMs merge terminally in the midline, thus bisecting the paired rectus abdominis muscles. Given its completely avascular nature, it is a preferred location for incision and intra-abdominal access. However, the completely fibrous nature of this structure with implied lack of muscular coverage leads to weakness and the formation of the majority of de novo ventral hernias [16]. Additionally, as most intra-abdominal access occurs via a midline laparotomy, the linea alba is the location of most iatrogenic hernias as well.

Ultimately, the goal of abdominal wall reconstruction remains to restore linea alba by bringing the paired rectus muscles back to the midline. For patients with massive hernias and loss of domain, this is accomplished with various myofascial or musculocutaneous advancement techniques. Once complete, restoration of linea alba has been shown to improve isokinetic and isometric function of the abdominal wall and ultimately quality of life [17]. In the modern era of abdominal wall reconstruction, this functional restoration is critical for not only a complete repair but one that maintains the integrity and actions of the whole abdominal wall unit.

Rectus Abdominis

The rectus abdominus muscles (RA) are the predominant component of the midline group, flanking the linea alba on each side. Occurring as paired strap-like muscles, they are distinctly unlike the broad muscles of the anterolateral group. The recti originate from the pubic crest and ligamentous portion of the pubic symphysis, the fibers course superiorly to insert onto the xiphoid process and anterior surface of the 5th–7th costal cartilages bilaterally. The linea alba bisects the two recti, where the aponeuroses of the anterolateral group decussate and fuse to form the tendinous line. There also exist approximately 3–4 separate tendinous bands that occur at variable points along the rectus in a transverse manner. These bands are irregular in nature and do not necessarily occur along regular intervals, but function as transverse anchor points along the muscle body allowing for flexion of the trunk. A strong attachment of the rectus is found to the anterior rectus sheath with posterior sheath attachment occurring more variably [18].

Vascular supply to the rectus muscles is distinctly different from the anterolateral group, with blood supply originating from paired superior epigastric arteries (SEAs) and deep inferior epigastric arteries (DIEAs), which run along the deep surface of the rectus after perforating the posterior sheath. Anastomotic connection between these two systems is generally found just above the umbilical area. The SEA vessels originate as terminal branches of the internal mammary artery around the level of the sixth costal cartilage. The SEAs enter the rectus sheath at the midpoint of the xiphoid process. The DIEAs arise as branches from the external iliac arteries just proximal to their course through the femoral ring where the external iliac arteries become the femoral arteries. The DIEAs serve as the pedicles for perforator techniques such as the TRAM (transverse rectus abdominis myocutaneous) and DIEP (deep inferior epigastric perforator) flaps seen in plastic surgery. Innervation, unlike vascular supply, is similar to that of the anterolateral group with the ventral rami of T6/7–L1 traveling in the transversus abdominis plane (TAP) to perforate the rectus sheath laterally. Sacrifice of these neurovascular perforating bundles during surgery can lead to atrophy of the rectus complex and should be avoided whenever possible. Ultimately, preservation of the neurovascular supply leads to maintenance of native rectus function and thus a more robust and functional repair.

The rectus abdominis is responsible primarily for flexion of the abdominal wall as well as assistance with increasing intra-abdominal pressure. Flexion of the abdominal wall can be the movement of the ribcage toward the pelvis, the pelvis toward the rib cage or both if neither point of flexion is fixed. The increase in abdominal pressure has contributions to various bodily functions including exhalation, defecation, and micturition. While the rectus is not necessarily engaged in any significant capacity during normal effort, it comes into play when these functions are forceful.

Clinically, it is important to return the rectus muscles back to the midline to recreate linea alba in order to allow for restoration of function. Without the central anchor point in the linea alba, the forces exerted by both the rectus muscles and the lateral abdominal wall are unlikely to translate to physiologic action that constitutes a truly functional repair.

Pyramidalis

The pyramidalis muscles are the second and most variable component of the midline group, with reported absence in 10–70% of the population on one or both sides [13]. The paired triangular muscles lie between the anterior surface of the rectus abdominis and associated anterior sheath caudal to the arcuate line. The fibers course superomedially, originating from the pubic crest and ligamentous portion of the pubic symphysis, inserting onto the linea alba. The function of the pyramidalis is not well understood, however it is thought to play a supplementary role in tensing the linea alba and increasing intra-abdominal pressure thus providing local compression of the bladder during micturition [12]. Given the variability in its occurrence in the population, the clinical significance of this muscle is essentially negligible.

Transversus Abdominis Muscle

The innermost muscle in the anterolateral group is the TAM. It lies directly under (dorsal to) the IOM and above (ventral to) the transversalis fascia. The muscle fibers originate from the inner surfaces of the 7th–12th costal cartilages, anterior leaflet of the thoracolumbar fascia, iliac crest, and lateral third of the inguinal ligament. These fibers course medially from their posterolateral origins in a largely horizontal manner until they insert onto the linea alba, pubic crest, and pectineal line. Superiorly, the fibers interdigitate with those of the diaphragm and travel in a more superior-medial manner. Moving inferiorly, there is a significant aponeurotic component to the muscle, which occurs closer to the midline at the inferior extreme, though clinically there is significant variation to the extension of the fibers toward the recti.