2 Anatomy and Physiology of the Abdominal Wall: A Surgeon's Guide to Hernia Repair

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The Question

Clinical Scenario

Scenario 1

A 50-year-old average-build woman presented to the surgical outpatient department (OPD) with complaints of a right groin lump. She and her family were in distress as she had undergone a second surgery for the same complaint just 3 months ago at a teaching medical college. Unable to understand why her past two surgeries for inguinal hernia repair had resulted in recurrences, she presented for a second opinion.

On examination, there was a scar corresponding to an open Lichtenstein repair along with a bulge and cough impulse over the inguinal crease.

What would you do next?

Scenario 2

A 56-year-old man who underwent a hernia repair in his village 10 months ago presented to the OPD for a nonhealing wound over the abdominal wall (**Fig. 2.1**). He states that the wound does not bother him much as he is unable to sense any pain around the area, but as the wound persists, it soils his clothes, making it uncomfortable.

What do you think happened?



Fig. 2.1 Nonhealing wound over the abdomen in a 56-year-old man with a history of hernia repair 10 months ago. (Used with the permission of Dr Muhammed Nadeem Mehmood).

ERM, PKB

Learning Objectives

After reading this chapter, the reader should be able to:

- Recognize the neurovascular anatomy and layers of the abdominal wall, anatomical landmarks, and boundaries of potential hernia sites.
- Understand the function of the abdominal wall and the implications of neurovascular and muscle anatomy on procedural steps for hernia repair.
- Apply anatomical knowledge to distinguish hernial defects and select planes for mesh placement.
- Analyze how prior incisions, muscles, or fascial quality, neurovascular integrity, would affect the choice of procedure, approach, or incision for a hernia repair.
- Judge the risk-benefit of mesh fixation in different areas of the abdominal wall and evaluate different abdominal planes for mesh placement in a hernia.
- Create an operative strategy for a hernia integrating abdominal wall anatomy, mesh planes, and neurovascular sparing strategies.

Keywords

transversalis fascia, arcuate line, linea alba, myopectineal orifice, Hesselbach's triangle, preperitoneal spaces—Bogros and Retzius, external oblique aponeurosis, internal oblique muscle, transversus abdominis muscle, linea semilunaris, corona mortis, triangle of doom, triangle of pain, loss of domain

Foundational Anatomy

Overview

A good understanding of the anatomy of the abdominal wall is essential for safe and complication-free hernia surgery. Whether performing an open, laparoscopic, or robotic repair, understanding of the abdominal wall's structural organization, fascial planes, and neurovascular elements determines operative success and minimizes chronic pain and recurrence. The abdominal wall is a mechanical barrier and a dynamic composite structure that transmits vector forces, maintains intra-abdominal pressure (IAP), and provides the functional substrate for movement and respiration. The modern hernia surgeon, whether working through an open, laparoscopic, or robotic platform, must visualize not only layers, vessels, and nerves but also the three-dimensional dynamics of the myofascial envelope, the load-bearing fascial planes, and the zones of predilection where defects emerge.

A hernia surgeon should recognize distinct layers during dissection and mesh placement. The surgeon must understand the transitions between muscular and aponeurotic zones, the behavior of fascia under tension, and the anatomic variability that accompanies age, obesity, and prior surgery.

Layer-by-Layer Anatomy of the Anterolateral Abdominal Wall: The Nine Layers from Skin to Peritoneum

For operative planning, especially in the context of hernia repair, component separation, and reconstructive procedures, the flat multilayer system of the abdominal wall is understood as a myofascial composite, with interdigitating fibers, zones, and embedded neurovascular laminae (**Fig. 2.2**).

Layer 1: Skin

The skin is elastic, highly vascular, and loosely adherent, except at the umbilicus. Its vascular and lymphatic network is relevant during open incisions and anterior component separation (ACS). It receives segmental innervation from the anterior and lateral cutaneous branches of

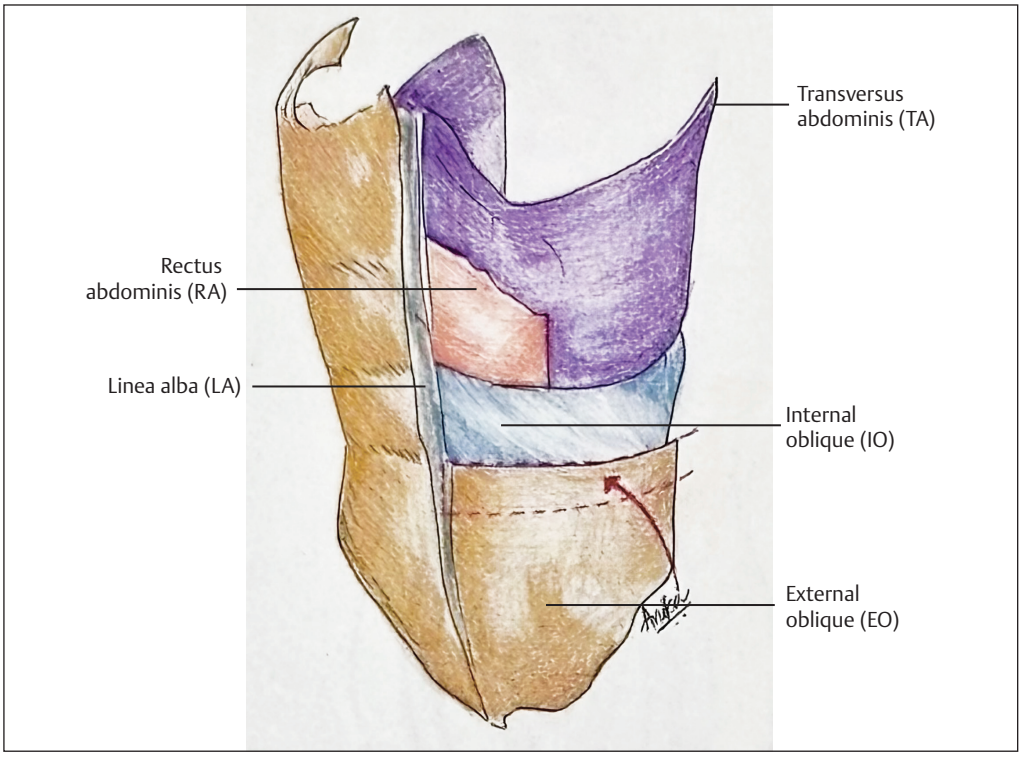


Fig. 2.2 Layered musculoaponeurotic anatomy of the anterior abdominal wall. (Used with the permission of Anika H Zaveri).

T7–T12, with T10 corresponding to the umbilical level. Skin perfusion depends critically on the integrity of perforators from the deep inferior epigastric and intercostal arteries. Poorly planned skin flaps may compromise perfusion.[1]

Layer 2 and Layer 3: Superficial Fascia (Camper and Scarpa)

- **Camper's fascia:** Fatty, variable thickness.
- **Scarpa's fascia:** Deep membranous, well-defined inferiorly, clinically relevant because it fuses with the fascia lata below the inguinal ligament.[1]

Scarpa's fascia thickens below the umbilicus and is used for flap creation during open ACS. Its integrity is essential for layered closure.[2]

Layer 4: External Oblique Aponeurosis

The external oblique (EO) forms the most superficial muscular layer. Its fibers run inferomedially, a pattern described consistently in classical European anatomy and modern imaging texts.[1]

The EO arises from the lower eight ribs and runs inferomedially ("hands-in-pockets" direction). Its aponeurosis forms the anterior layer of the rectus sheath and contributes to the inguinal ligament, extending from the anterior superior iliac spine to the pubic tubercle.[1]

In open anterior hernia repairs (e.g., Lichtenstein), division of the EO aponeurosis is the first true fascial step, exposing the inguinal canal and its neurovascular structures. Superior fibers of the EO aponeurosis fan across the linea alba to blend with the collateral aponeurosis, forming the reflected inguinal ligament that reinforces the medial floor of the canal.[2]

Layer 5: Internal Oblique Muscle

The internal oblique (IO) lies deep to EO, with fibers running superomedially. The IO arises from the thoracolumbar fascia, iliac crest, and lateral inguinal ligament; the aponeurosis splits

around the rectus abdominis above the arcuate line to form both anterior and posterior sheaths. Below the arcuate line, all fibers pass anterior to the rectus, contributing to the structural discontinuity that defines this level.[1,3]

The neurovascular plane between the IO and the transversus abdominis (TA) must be preserved during dissection (particularly transversus abdominis release [TAR] and laparo-endoscopic groin repair) to avoid iliohypogastric or ilioinguinal nerve injury. At the internal ring, IO fibers arch over the spermatic cord (or round ligament) to form the cremasteric muscle fibers, which are an important landmark in both open and laparoscopic hernia repair.

Layer 6: Transversus Abdominis Muscle

TA fibers, the innermost of the three flat muscles, run horizontally, providing circumferential support, an essential abdominal "corset." Its aponeurosis contributes to the posterior rectus sheath above the arcuate line and passes entirely anterior to the rectus below it.

Flament emphasizes that TA is the key stabilizer of IAP and forms the deepest muscular boundary before the transversalis fascia (TF).[1] Acting synergistically with the diaphragm and pelvic floor, it maintains IAP.

This muscle's aponeurotic plane forms the foundation for modern component separation techniques, particularly TAR, which utilizes the potential space between the TA and the TF to achieve wide medial advancement without devascularizing the overlying rectus muscles. Surgical rehabilitation of TA function is critical in restoring abdominal core integrity following large hernia repair. Superior to the costal margin, the posterior rectus sheath disappears entirely, since the TA continues cranially as the transversus thoracis and the IO attaches to the costal margin, leaving the rectus muscle applied directly to the thoracic wall at this level.[2] **Fig. 2.3** shows the cross-sectional anatomy of the abdominal wall and surgical mesh planes.

Layer 7: The Transversalis Fascia—The Critical Load-Bearing Layer

Historically underappreciated, the TF is now recognized as the principal tensile layer of the posterior abdominal wall, a thin but resilient

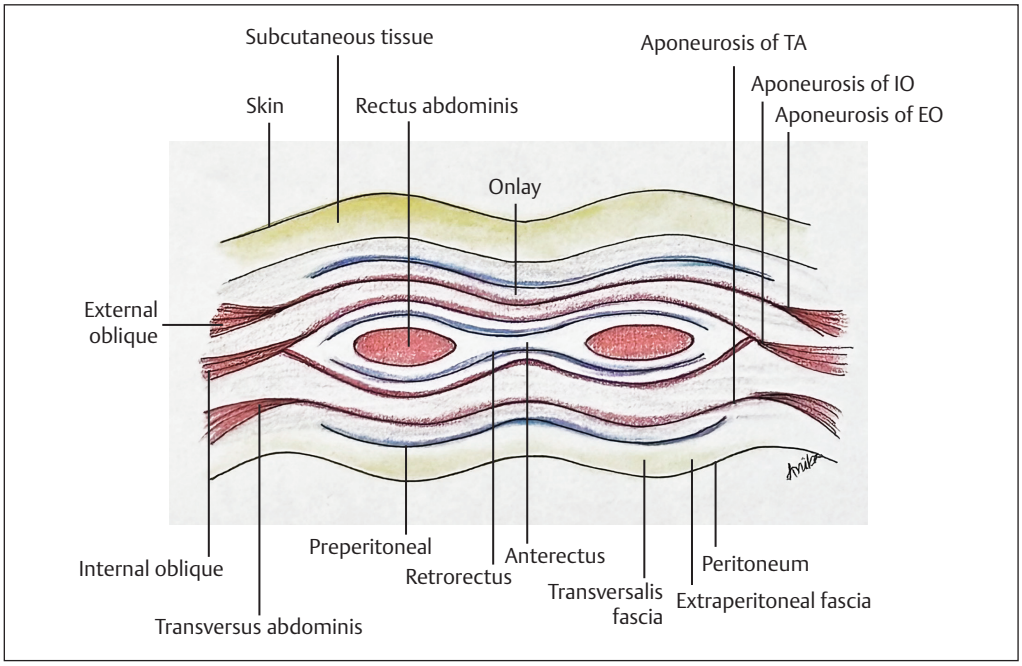


Fig. 2.3 Cross-sectional anatomy of the abdominal wall and the surgical mesh planes. EO, external oblique; IO, internal oblique; TA, transversus abdominis. (Used with the permission of Anika H Zaveri).

fibroelastic membrane that lines the inner surface of the TA muscle and separates it from the preperitoneal fat and peritoneum.[1,4]

Histologic Structure and Biomechanics

Peiper et al[5] demonstrated the following:

- Dense collagen matrix (type I predominant).
- Low elastin content.
- Age-related thinning.
- Significantly reduced tensile resistance in chronic hernia patients.[6]

Asakage later clarified TF as the outermost lamina of the extraperitoneal space, not merely a "thin sheet," but part of a vascular fascial system connecting the diaphragm to the pelvis.[4]

Clinical Implications

- Direct inguinal hernias result from TF attenuation.
- All posterior groin repairs (totally extraperitoneal [TEP], transabdominal preperitoneal [TAPP], Stoppa) reinforce TF and its associated preperitoneal fasciae.
- TAR deliberately separates TA from TF, proving they are distinct anatomical entities.

Layer 8: Preperitoneal (Extraperitoneal) Space

The preperitoneal space, described historically by Bogros, Retzius, and later unified by modern anatomists, is a three-dimensional continuous compartment extending from the pubis to the diaphragm.[6]

It contains the following:

- Inferior epigastric vessels (IEVs).
- Corona mortis variants.
- Cooper's ligament.
- Vesicohypogastric and urogenital fasciae.
- Key mesh-receiving platforms (TEP/TAPP, Rives–Stoppa).

Understanding this space is essential for safe minimally invasive hernia surgery. The space of Bogros lies lateral to the IEVs, while the space of Retzius lies medially, between the bladder and the pubic symphysis. It allows surgeons to dissect atraumatically and create wide, bloodless spaces for mesh coverage across the myopectineal orifice (MPO). This anterolateral potential space between the TF and the parietal peritoneum is the same avascular plane exploited for the prosthetic mesh placement during open and laparoscopic inguinal hernia repair.[2]

Layer 9: Peritoneum

The parietal peritoneum forms the innermost lining of the abdominal cavity. In hernia surgery, it serves as both a landmark and a protective barrier for intra-abdominal viscera. In TAPP repairs, it is incised and later closed over the mesh to reestablish the peritoneal barrier; in TEP, it forms the posterior limit of safe dissection.

The peritoneum's inherent elasticity is crucial for maintaining the integrity of the preperitoneal space; excessive trauma or thermal injury here predisposes to seroma formation and postoperative adhesions.

Vector Mechanics of Muscular Support

The abdominal wall functions as a single myofascial symphony of muscles that transmits multidirectional forces. The mechanical stability arises from coordinated contraction of the EO, IO, TA, diaphragm, and pelvic floor, forming a circumferential pressurization cylinder that maintains IAP, facilitates locomotion, and resists herniation.[1]

Comparative Muscle Tables: Abdominal Wall Myofascial System

A comparison of the muscles of the abdominal wall myofascial system is presented in **Tables 2.1** to **2.4**.

Anatomic Variability: Age, Gender, BMI, and Prior Surgery

The anatomy of the abdominal wall varies significantly with demographic and physiologic factors.

Table 2.1 The lateral flat muscle groups IO, EO, TA: These muscles primarily contribute to dynamic core stability, rotation, and load transfer

Muscle	Origin	Insertion	Fiber direction	Primary action	Innervation	Surgical relevance
External oblique (EO)	Outer surfaces of ribs 5–12	Linea alba, pubic tubercle, anterior iliac crest, inguinal ligament	Inferomedial ("hands-in-pockets")	*Contralateral trunk rotation*, trunk flexion, increases IAP	T7–T12 intercostal nerves	Divided in open inguinal repair; forms inguinal ligament; superficial aponeurosis
Internal oblique (IO)	Thoracolumbar fascia, iliac crest, lateral inguinal ligament	Costal cartilages of ribs 10–12, linea alba; contributes to rectus sheath	Superomedial	*Ipsilateral trunk rotation*, trunk flexion, assists forced expiration	T6–T12 + L1 (iliohypogastric and ilioinguinal)	Forms cremaster; neurovascular plane deep to IO—critical in TAR, TEP
Transversus abdominis (TA)	Thoracolumbar fascia, inner surfaces of ribs 7–12, iliac crest, lateral inguinal ligament	Linea alba, pubic crest, pectineal line	Horizontal	Core stability, IAP maintenance; minimal direct rotation	T7–T12 + L1	Deepest flat layer; key plane for TAR; forms posterior sheath above arcuate

Abbreviations: IAP, intra-abdominal pressure; TAR, transversus abdominis release; TEP, totally extraperitoneal.

Table 2.2 Anterior midline muscles (rectus, pyramidalis)

Muscle	Origin	Insertion	Action	Innervation	Surgical notes
Rectus abdominis (RA)	Pubic symphysis and crest	Costal cartilages 5–7, xiphoid	Trunk flexion, stabilizes the pelvis	T6–T12 segmental	Interrupted posterior sheath below arcuate → vulnerable plane for intraperitoneal contact
Pyramidalis	Pubis (anterior)	Linea alba (lower portion)	Tenses linea alba	Subcostal nerve (T12)	Often absent; used as an anatomical marker

Table 2.3 Posterolateral and diaphragmatic interface group

Muscle	Origin	Insertion	Action	Innervation	Relevance
Quadratus lumborum (QL)	Iliac crest	12th rib + lumbar transverse processes	Stabilizes the 12th rib, lateral flexion	T12–L4	Forms posterior abdominal wall; encountered in flank hernias
Psoas major	T12–L5 vertebral bodies	Lesser trochanter	Hip flexion, spinal stabilization	Lumbar plexus L1–L3	Landmark for iliopsoas hernias; crucial in retroperitoneal dissection
Diaphragm interface (costal fibers)	Inner costal margin	Central tendon	Respiration, IAP regulation	Phrenic nerve (C3–C5)	Synergistic pressure regulation with TA during coughing, lifting

Abbreviations: IAP, intra-abdominal pressure; TA, transversus abdominis.

Table 2.4 Functional summary table: comparative biomechanics

Function	Primary muscles	Mechanism	Surgical significance
Rotation (right trunk rotation)	Left EO + right IO	Cross-body torque via decussating aponeuroses	Hernias arise at decussation gaps → midline defects
Core pressurization and corset effect	TA + diaphragm + pelvic floor	Circumferential tension + respiratory synergy	TAR restores functional core stability
Midline flexion	Rectus abdominis	Sagittal plane bending	Posterior sheath absence below arcuate → risk of organ adherence
Inguinal stabilization	IO + EO + cremaster	Arching over the spermatic cord	Relevant for indirect hernia formation

Abbreviations: EO, external oblique; IO, internal oblique; TA, transversus abdominis; TAR, transversus abdominis release.

Body Habitus and Fat Distribution

Computed tomography (CT) studies demonstrate that women accumulate more subcutaneous abdominal fat, whereas men accumulate more visceral fat, a key factor in trocar entry, plane recognition, and mesh placement.

Higher body mass index (BMI) increases the following:

- The thickness of Camper's fascia → difficult ACS flaps.
- IAP → increased recurrence risk.
- The distance to the preperitoneal plane during TEP/TAPP repair.

Age-Related Changes

Aging produces the following:

- Reduced collagen type I:III ratio → lower tensile strength.
- Thinning of TF → predisposition to direct hernias.
- Lower rib descent → inferior course of intercostal nerves in the elderly.

Separation of the paired recti at the linea alba (rectus diastasis) occurs physiologically in the neonate and in pregnancy, becomes more pronounced with increased IAP such as during a sit-up, and has been reported in association with abdominal aortic aneurysm and HIV-associated lipodystrophy in adults.[7]

Sex-Specific Differences

- **Women:** Wider pelvis, greater fascial elasticity → different inguinal defect patterns.
- **Men:** Larger inguinal canal, cremaster development → higher indirect hernia incidence.

Postoperative (Scar) Variability

Multiple incisions isolate fascial "islands" with poor neovascularization, increasing wound failure risk.

Midline Structures

Linea Alba

The linea alba is a thick, vertically oriented aponeurotic raphe extending from the xiphoid to the pubic symphysis.[1,3] It represents interdigitating fibers from the three lateral muscle aponeuroses, forming the central load-bearing midline structure.

Imaging shows the following:

- Approximately 3 cm lateral extension from midline.
- High echogenicity on ultrasound and CT.
- Reduced muscular reinforcement above the umbilicus → epigastric hernia susceptibility.

Biomechanical significance:

- Decussating fibers transmit left–right oblique forces across midline.
- Weakness arises where decussation is incomplete (epigastric zone) or where posterior sheath transitions (near the arcuate line).[3]

Clinical note: *Defects at the linea alba require midline fascial restoration, not simply mesh coverage, to restore force transmission.*

Cutaneous Innervation of the Abdominal Wall

The anterolateral abdominal wall receives segmental innervation from the following:

- T5–T12 intercostal nerves (dermatomes run horizontally; T10 = umbilicus).
- Iliohypogastric and ilioinguinal (lower abdominal wall, groin, genital region).
- Genitofemoral nerve (motor to cremaster; sensory to genital root).
- Subcostal nerve (T12)—major motor to flat muscles in the elderly due to the inferior course.

Surgical relevance:

- Nerves course between IO and TA.
- Preservation is essential during TAR and laparo-endoscopic groin repair.
- Subcostal and 11th intercostal nerves are endangered in flank incisions (**Fig. 2.4**).

Semilunar Line and Spigelian Fascia

The transition from muscular fibers (IO, TA) to aponeurosis creates a natural deficiency at the linea semilunaris where Spigelian hernias arise, often at or below the arcuate line where posterior sheath support is absent (**Fig. 2.5**).

The Arcuate Line and Posterior Sheath Transition

The arcuate line is located approximately midway between the umbilicus and pubic symphysis. Above it, the rectus abdominis is enveloped by both anterior and posterior sheaths; below it, the posterior sheath ends, and only the TF and peritoneum separate the rectus from intra-abdominal contents.[3]

This anatomical transition has immense surgical implications:

- It defines the entry into the retromuscular (Rives–Stoppa) space.
- It marks the inferior limit of safe posterior dissection in TAR.
- Hernias that occur near this line often display atypical presentations due to sheath discontinuity (**Fig. 2.6**).

Arcuate Line

This anatomical boundary marks the following:

- Loss of posterior rectus sheath.
- Rectus lying directly on TF.

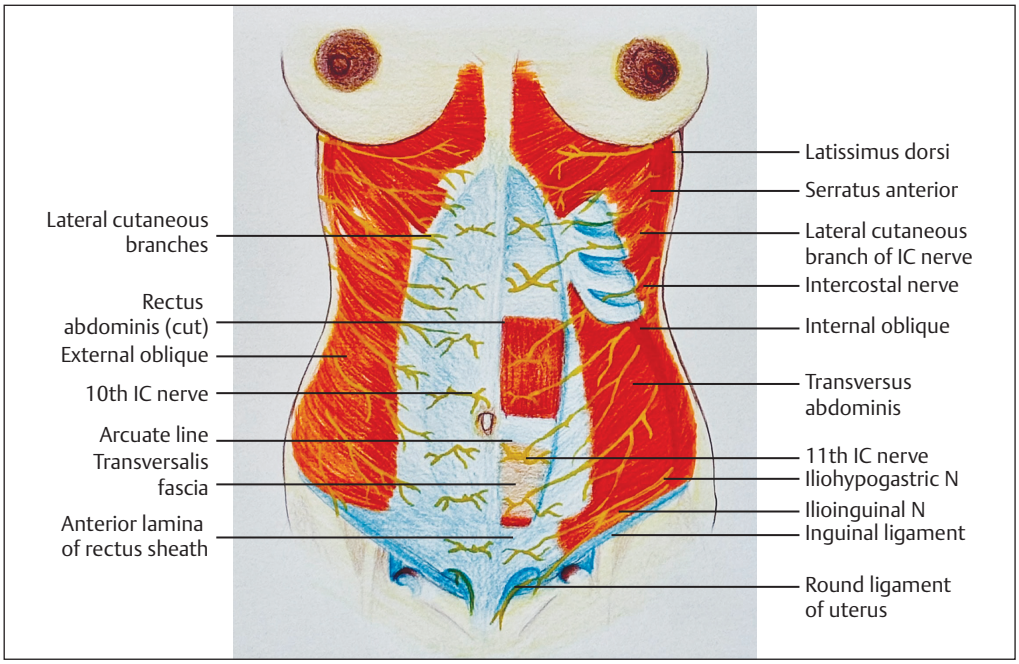


Fig. 2.4 Segmental nerve supply of the anterior abdominal wall. (Used with the permission of Dhanashree S Kharche).

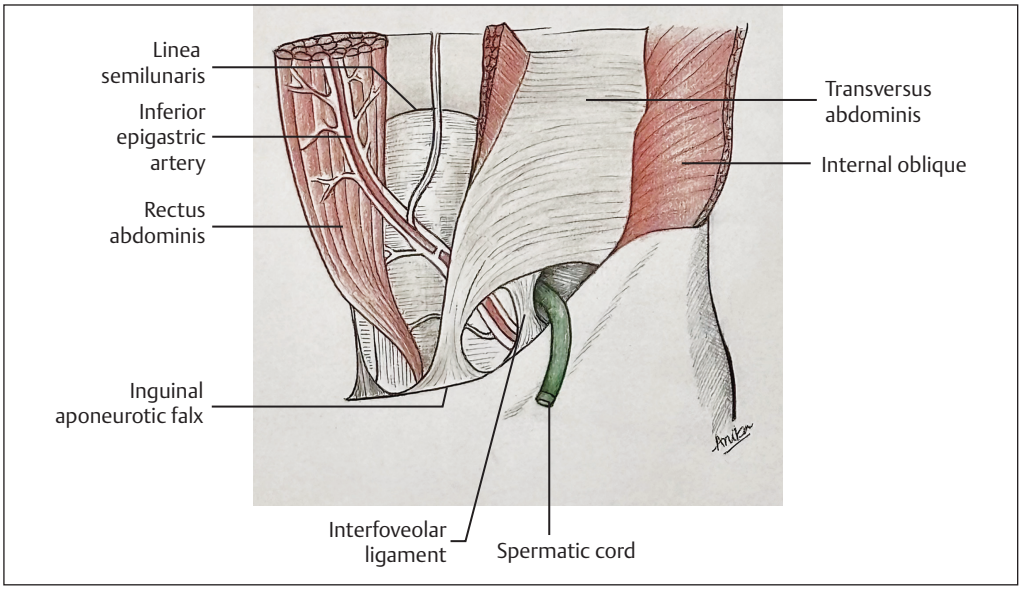


Fig. 2.5 Linea semilunaris, inferior epigastric vessels, and inguinal aponeurotic anatomy. (Used with the permission of Anika H Zaveri).

- Entry point for TAR.
- Key landmark for retromuscular mesh placement (Rives–Stoppa).

Conze's "fatty triangle," a zone created during posterior sheath release, sits just above the arcuate line and is essential for adequate mesh overlap in sublay repairs.[3]

Microscopic and Biomechanical Insights

At the microscopic level, the abdominal wall fasciae exhibit hierarchical collagen architecture.

- **Type I collagen** predominates in healthy, load-bearing fascia (e.g., TF, rectus sheath).
- **Type III collagen**, associated with immature or healing tissue, is overexpressed in incisional hernia sites and scarred fascia, leading to diminished tensile strength.

Studies demonstrate that the type I/III collagen ratio decreases with age and chronic inflammation, correlating with higher recurrence rates after hernia repair.

Surgeons must therefore recognize that the quality of fascia is as critical as its quantity, emphasizing the need for wide mesh overlap and atraumatic fixation techniques.

Langer's Lines

Langer's lines represent natural skin tension vectors formed by collagen fiber orientation. In the abdomen, lines run transversely above the umbilicus and more obliquely below.

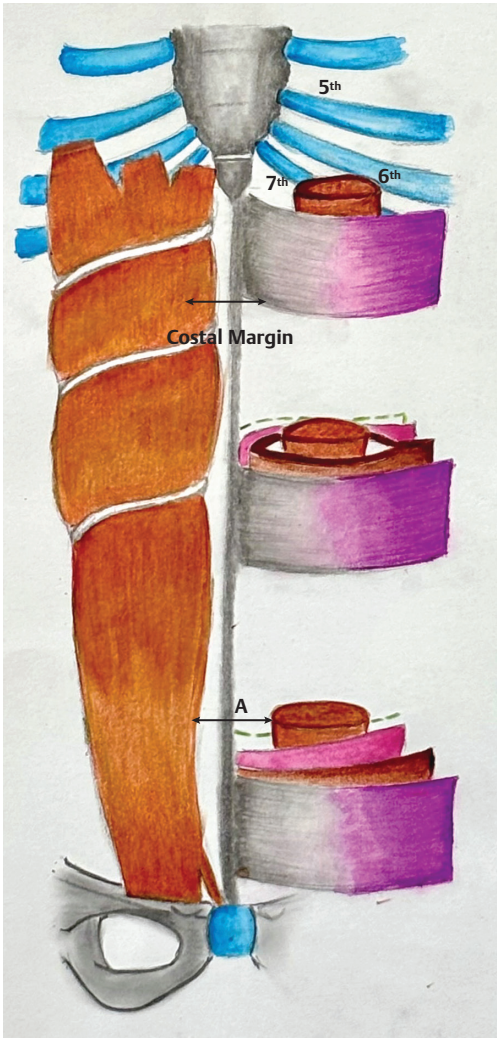
Surgical Implications

- Transverse incisions → better cosmesis, decreased hypertrophic scarring.
- Vertical incisions → easier exposure but higher wound dehiscence in obese patients.
- Incision planning must balance cosmesis versus access versus blood supply.

Surgical Pearl Summary

- Always identify and preserve Scarpa's fascia during flap elevation to maintain vascularity and facilitate layered closure.
- The TF, not the peritoneum, is the true tension-bearing layer in posterior repairs.
- Dissection should respect natural avascular planes: between Scarpa's and EO aponeurosis (superficial) and between TF and peritoneum (deep).
- Hernia susceptible regions, linea alba, linea semilunaris, and arcuate line, represent

Walls: Rectus sheath is divided into 3 levels



1. *Above the level of costal margin:*

   Anterior wall: External oblique aponeurosis.

   Posterior wall: 5th, 6th & 7th costal cartilage.

2. *From the costal margin to point A (midway between the umbilicus & the pubic symphysis)*

   Anterior wall: external oblique aponeurosis & the anterior lamina of the internal oblique aponeurosis.

   Posterior wall: Posterior lamina of internal oblique aponeurosis & the transversus abdominis. Lower limit of the posterior wall is the **arcuate line**.

3. *From point A (arcuate line) to symphysis pubis:*

   Anterior wall: aponeurosis of the external, internal oblique & transversus abdominis muscles.

   Posterior wall: fascia transversalis.

Fig. 2.6 Anatomical variation of the rectus sheath above and below the arcuate line. (Used with the permission of Juily Satam).

transitions between muscular and aponeurotic structures, demanding careful reinforcement.

Applied Anatomy of the Inguinal Region

Introduction

The inguinal region is the most anatomically complex and surgically important zone of the abdominal wall. It has the highest number of hernia defects, complex neurovascular relationships, and important fascial transitions in the lower abdomen. For the hernia surgeon, pristine knowledge of this region, from both anterior and posterior perspectives, is important for safe, standardized repair procedures, which are reproducible with the avoidance of complications in the short and long-term.

Historically, descriptions by Cooper, Hesselbach, Scarpa, and Fruchaud laid the foundation for understanding this region.[6,8,9] Modern reevaluation through laparoscopy,

robotics, high-resolution imaging, and detailed cadaveric microdissection has clarified the three-dimensional architecture of the inguinal canal, preperitoneal space, and the MPO.[1,3,4,6,9] These insights underpin all contemporary techniques, including Lichtenstein, Shouldice, TEP, TAPP, and robotic trans abdominal preperitoneal (rTAPP) repairs.

The Inguinal Canal: The Dynamic Corridor

The inguinal canal is a 4- to 6-cm oblique myofascial tunnel, extending from the deep (internal) ring to the superficial (external) ring, transmitting the spermatic cord (male) or round ligament (female), along with nerves. It is not a fixed tube; it is a dynamic shutter mechanism created by muscular contraction, aponeurotic rotation, and fascial compression. In adults, the canal is approximately 4 cm long and runs parallel to, and just superior to, the medial half of the inguinal ligament[2] (**Fig. 2.7**).

Boundaries of the Inguinal Canal

Anterior Wall

- EO aponeurosis (primary component).
- Reinforced laterally by IO fibers.
- Surgical relevance: Incised in open repairs; suturing under tension risks nerve entrapment.

Posterior Wall

- TF.
- Medially reinforced by the conjoint tendon (IO + TA aponeurotic fibers).
- Surgical relevance: The weak zone of direct herniation. Medially, the posterior wall receives additional reinforcement from the reflected inguinal ligament, where fibers of the EO aponeurosis sweep upward across the linea alba to merge with the contralateral aponeurosis.[2]

Roof

- Arching fibers of IO and TA.
- Forms the "shutter" mechanism described by Lytle.

Floor

- Inguinal ligament.
- Lacunar (Gimbernat's) ligament medially.
- Surgical relevance: Femoral canal lies immediately inferior—a common site of missed hernias in open repair.

The Deep (Internal) Inguinal Ring

The deep ring is an elliptical defect in the TF, extending up to about 2 cm above the inguinal ligament at the midpoint between the anterior

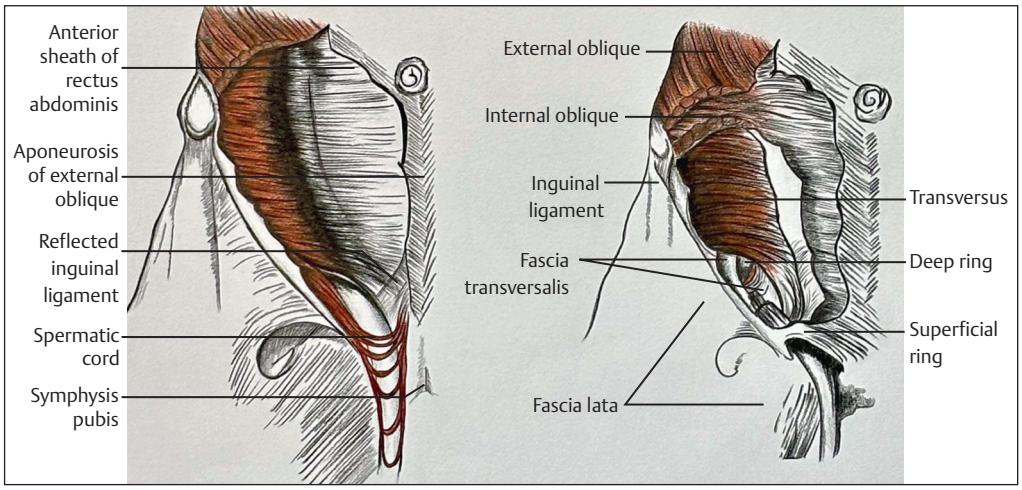


Fig. 2.7 Anatomy of the inguinal canal. (Used with the permission of Dhanashree S Kharche).

superior iliac spine (ASIS) and the pubic tubercle. From the posterior laparoscopic perspective, it appears as a round fascial window lateral to the IEVs[6] (**Fig. 2.8**).

Boundaries

- **Lateral:** TF and iliopubic tract.
- **Medial:** IEVs.
- **Posterior:** Preperitoneal space (Bogros).
- **Anterior:** IO fibers.

Surgical Implications

- Indirect hernia sacs originate *through* this ring, anterolateral to the cord.
- In TEP/TAPP repair, blunt reduction of the peritoneal sac must maintain the integrity of the vas deferens medially and gonadal vessels laterally.
- Injury to the ring risks postoperative cord adhesions or neuropathy (**Fig. 2.9**).

The Superficial (External) Ring

The superficial ring is a triangular opening in the EO aponeurosis, just above the pubic crest.

Boundaries

- **Medial crus:** Pubic symphysis.
- **Lateral crus:** Pubic tubercle.
- **Intercrural fibers:** Strengthen the opening.

Surgical Relevance

During Lichtenstein repair, over-dividing intercrural fibers or placing mesh fixation too close to the ring risks **ilioinguinal nerve entrapment**.

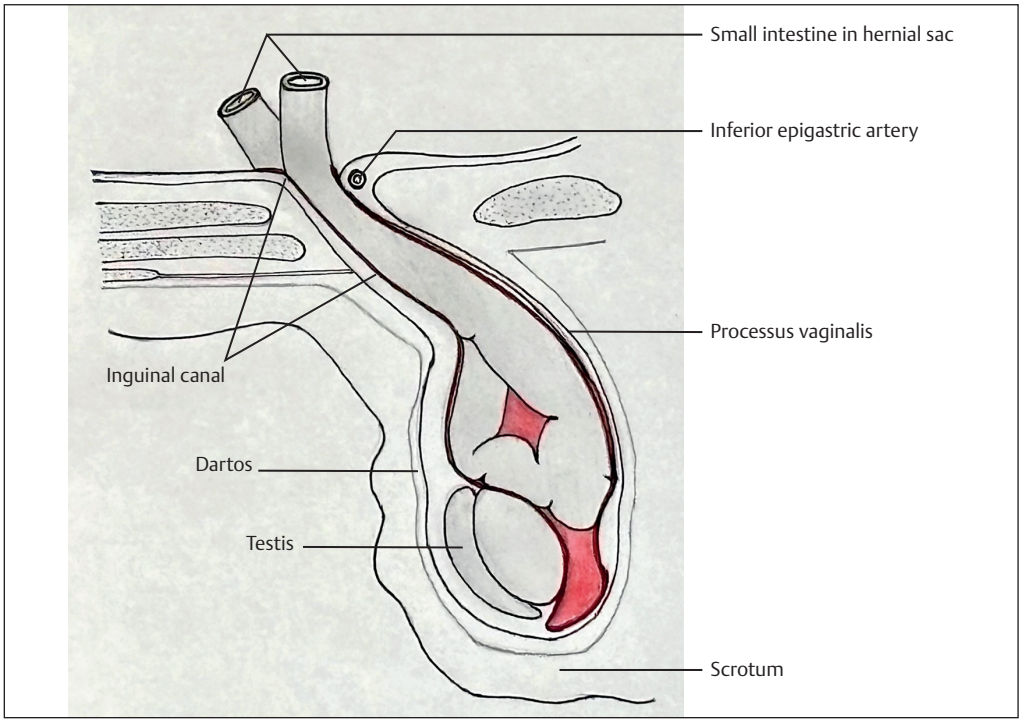


Fig. 2.8 Indirect inguinoscrotal hernia through a patent processus vaginalis. (Used with the permission of Sayed Ayesha Siddiqua Qasim).

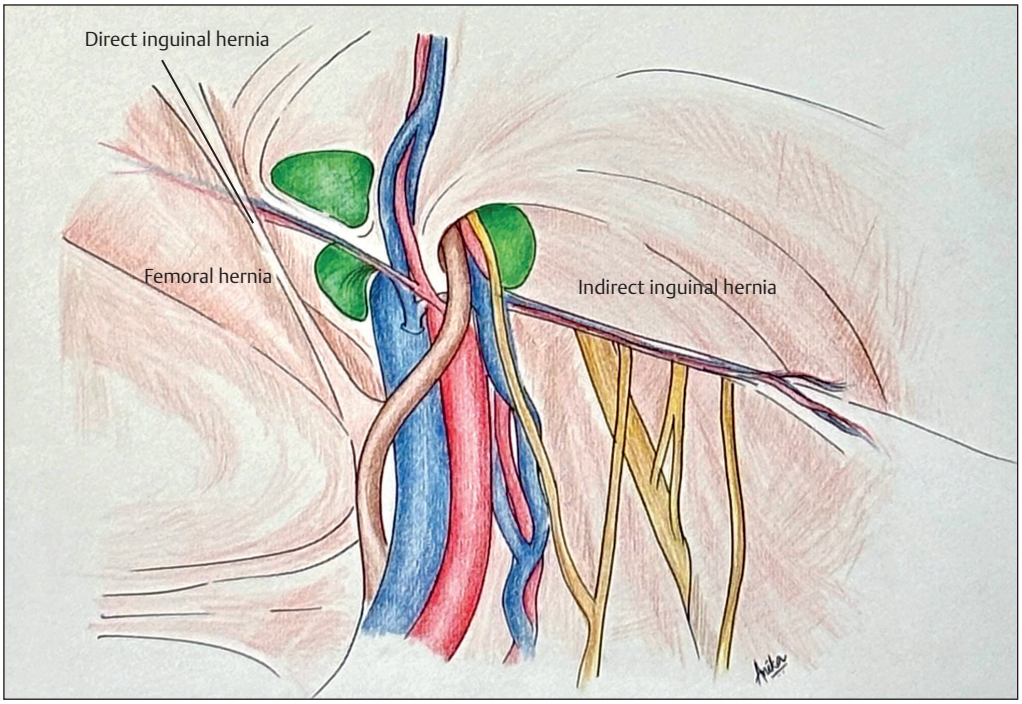


Fig. 2.9 Preperitoneal sites of the groin hernias on laparoendoscopy. (Used with the permission of Anika H Zaveri).

The Spermatic Cord and Round Ligament

Male Contents

Classically described:[9]

- Vas deferens.
- Testicular artery.
- Pampiniform plexus.
- Cremasteric vessels.
- Artery to vas deferens.
- Genital branch of the genitofemoral nerve.
- Lymphatics.
- Processus vaginalis remnant.

Female Contents

- Round ligament of the uterus.
- Accompanying artery and small nerves.

Anterior versus Posterior Distinction

- **Indirect sacs:** Anterolateral to the cord.
- **Direct hernias:** Medial to cord structures.
- **Femoral hernias:** Inferior to the inguinal ligament.

Hesselbach's Triangle

This critical anatomic triangle—first clearly defined by Hesselbach and modernized by Fruchaud—houses the origin of direct hernias.

Boundaries

- **Medial:** Lateral border of the rectus (linea semilunaris internally).
- **Lateral:** IEVs.
- **Inferior:** Inguinal ligament.

Surgical Significance

- The direct hernia "bulge" represents weakness of the TF, not muscle.
- Preperitoneal dissection must expose this triangle fully in TEP/TAPP before mesh deployment.

Recurrence after open repair often results from inadequate coverage of this area (**Fig. 2.10**).

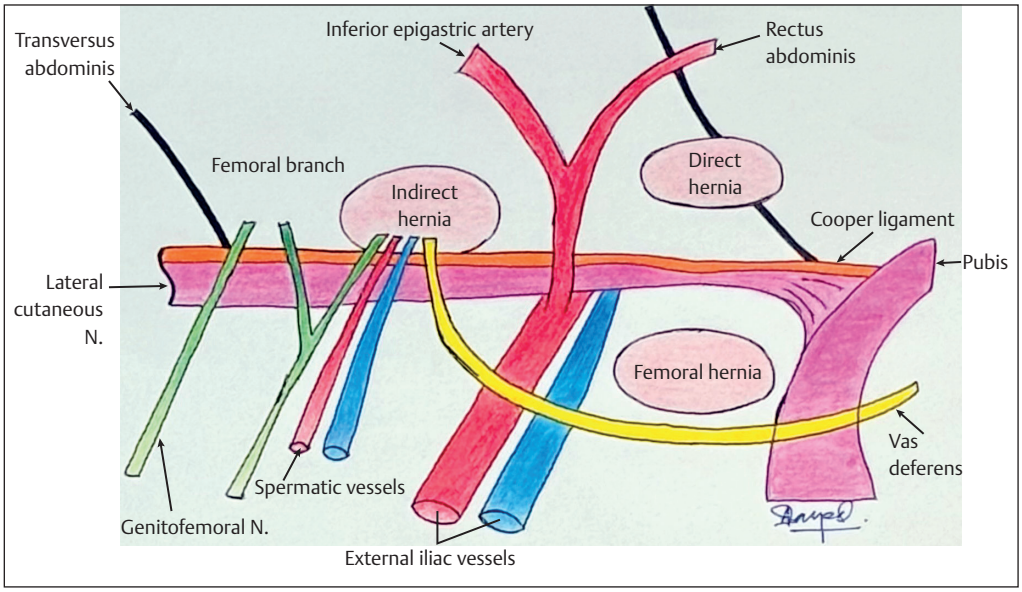


Fig. 2.10 Anatomical relation of the vessels and nerves to direct, indirect, and femoral hernias of the left side. (Used with the permission of Sayed Ayesha Siddiqua Qasim).

The Myopectineal Orifice: Fruchaud's Unifying Concept

The MPO is the single continuous anatomic zone of weakness through which all groin hernias—direct, indirect, femoral, obturator—occur. It is bounded by the following:

- **Superior:** Arching fibers of IO and TA.
- **Medial:** Lateral rectus sheath.
- **Lateral:** Iliopsoas muscle.
- **Inferior:** Cooper's ligament and pectineal line.
- **Anterior:** Inguinal ligament.
- **Posterior:** Preperitoneal fascia and peritoneum.

Fruchaud's work, expanded by modern laparoscopic studies, shows that comprehensive mesh coverage of the MPO is mandatory for durable repair.[8]

Vascular Anatomy: Critical Surgical Landmarks

Inferior Epigastric Vessels

IEVs arise from the external iliac vessels and course superomedially to enter the rectus sheath at the arcuate line.

Key Surgical Principles

- Landmark for distinguishing direct (medial) versus indirect (lateral) hernias.
- Must be identified before dissection of the deep ring in TEP/TAPP.[10]
- Injury results in significant retroperitoneal bleeding. The blood supply of the anterolateral abdominal wall is classically divided into three larger zones:
  - Zone I (upper/midcentral wall and deep superior and inferior epigastric arteries).
  - Zone II (lower wall, epigastric arcade, and superficial vessels).
  - *Zone III (flank, musculophrenic, lower intercostal, and lumbar arteries):* The deep inferior epigastric artery is the dominant vessel supplying the rectus abdominis, with a mean origin diameter of approximately 3.4 mm compared with 1.6 mm for the superior epigastric artery, the two systems anastomosing within the muscle between the xiphoid process and umbilicus (**Fig. 2.11**).[7]

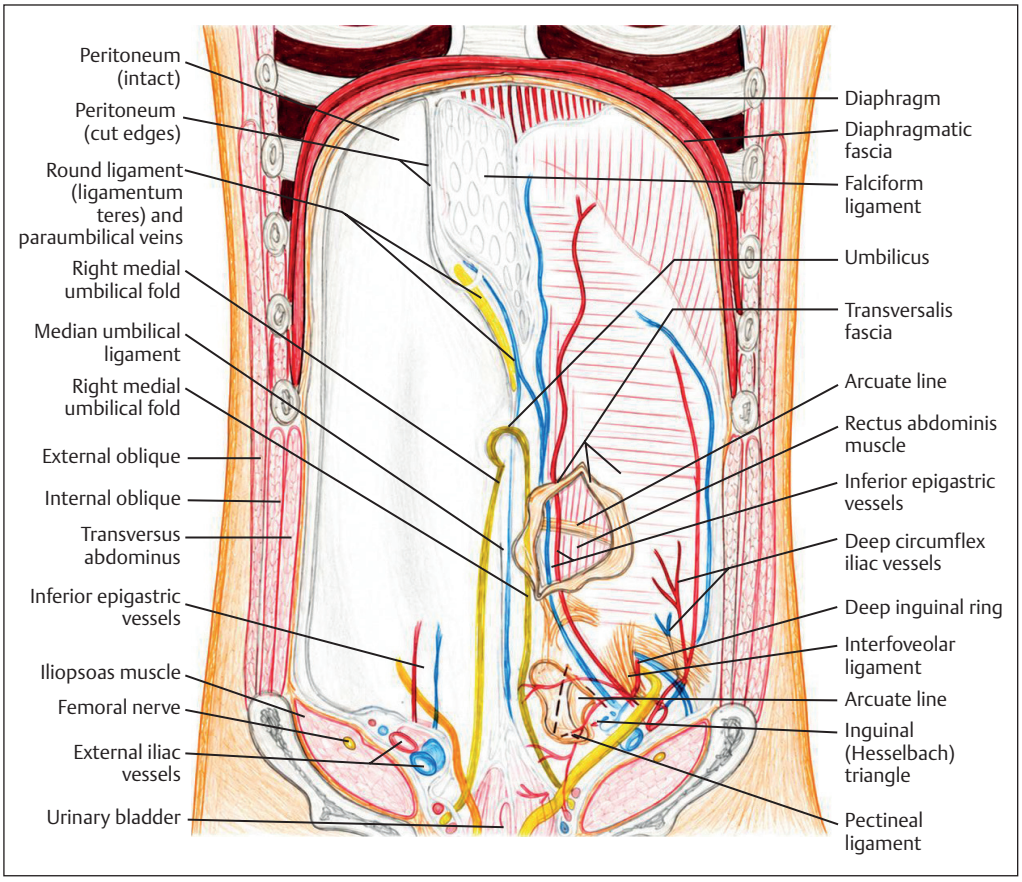


Fig. 2.11 Vascular territory of the abdominal wall. (Used with the permission of Arshad Abdul Majid Shaikh).

Femoral Triangle and Femoral Canal

Boundaries

- **Superior:** Inguinal ligament.
- **Lateral:** Sartorius.
- **Medial:** Adductor longus.

Femoral Sheath Compartments

- **Lateral:** Femoral artery.
- **Intermediate:** Femoral vein.
- **Medial:** Femoral canal (site of femoral hernia).

Mnemonic: **NAVEL** (nerve–artery–vein–empty–lymphatics).

Corona Mortis

An arterial or venous communication between obturator and inferior epigastric/external iliac systems.[6]

- Present in 20 to 30% of patients.[6]
- Courses over Cooper's ligament.
- **Surgical danger:** Life-threatening hemorrhage during dissection or fixation along Cooper's ligament in TAPP repair.

Nerve Anatomy and Preservation

Chronic postoperative inguinal pain often results from nerve injury. Knowledge of nerve pathways is essential.[6]

Iliohypogastric Nerve (T12–L1)

- Emerges lateral to the psoas.
- Pierces the IO ~2 to 3 cm above the ASIS.
- Courses between the IO and EO.
- *Injury site:* EO split in open repair.

Ilioinguinal Nerve (L1)

- Parallels the iliohypogastric nerve but lower.
- Enters the canal through the IO.
- Emerges at the superficial ring.
- *Injury:* Mesh entrapment beneath the pubic tubercle or overly deep sutures.

Genitofemoral Nerve (L1–L2)

- **Genital branch:** Travels with cord; vulnerable in open repair.
- **Femoral branch:** Lies lateral, at risk of tack fixation in TAPP/TEP.

Triangle of Pain

Bounded by the **iliopubic tract and gonadal vessels**—avoid fixation due to nerves.

Triangle of Doom

Between the **vas deferens and gonadal vessels**—contains external iliac vessels; no fixation allowed (**Fig. 2.12**).

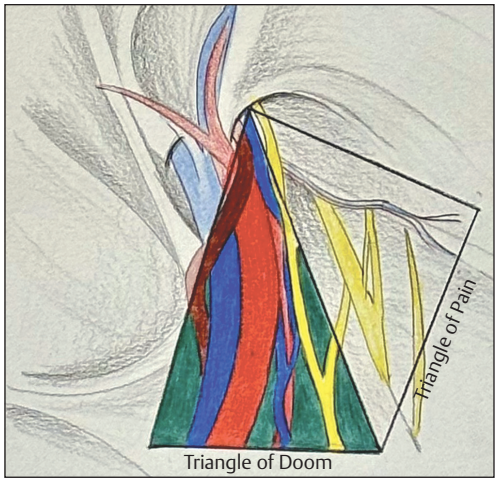


Fig. 2.12 Laparoscopic view of the triangle of doom and triangle of pain. (Used with the permission of Dhanashree S Kharche).

Mirilas and Skandalakis[11] detailed the intermuscular courses of these nerves extensively and emphasized preservation as the cornerstone of pain-free hernia surgery.[6]

Posterior (Laparoscopic/Robotic) Anatomy

Posterior repair exposes structures rarely appreciated in open anatomy.

Key Posterior Landmarks in TEP/TAPP

- Deep ring.
- IEVs.
- Hesselbach's triangle.
- Cooper's ligament.
- Psoas muscle and femoral nerve.
- Iliopubic tract.
- Femoral canal.
- Obturator space.

Critical View of the Myopectineal Orifice

This is a safe, reproducible laparoscopic principle analogous to the "critical view of safety" in cholecystectomy.

It must include the following:

- Full exposure of Cooper's ligament.
- Clear identification of IEVs.
- Visualization of direct, indirect, and femoral spaces.
- Recognition of vas and gonadal vessels.

Only after achieving critical view of the myopectineal orifice should mesh be deployed.

Applied Anatomy of Other Primary and Secondary Hernia Sites

Introduction

Beyond the inguinal canal and the MPO, the abdominal wall contains numerous inherent points of weakness—remnants of embryologic

passageways, fascial transitions, and neurovascular perforation zones. These regions give rise to femoral, umbilical, epigastric, Spigelian, lumbar, and incisional hernias.

Understanding these defects requires not only identifying the fascial boundaries but also appreciating the pathomechanics, collagen composition, load vectors, and fascial–bone relationships that dictate hernia behavior.

Modern anatomical treatises[1,9] and radiological studies[12] underscore that **each hernia type has a characteristic anatomic "signature"**—a predictable combination of boundary rigidity, defect geometry, and local tissue quality.

Femoral Hernia Anatomy

Femoral hernias represent **the most dangerous groin hernia**,[8,9] due to their narrow neck, rigid bony boundaries, and high rate of incarceration (**Table 2.5**).

Anatomical Boundaries of the Femoral Ring

The femoral ring is a **nondistensible osteofascial aperture** bordered by the following:

- **Anterior:** Inguinal ligament.
- **Posterior:** Pectineal fascia and Cooper's ligament.
- **Medial:** Lacunar (Gimbernat's) ligament.
- **Lateral:** Femoral vein.

The lacunar ligament, a dense crescent-shaped expansion of the inguinal ligament, creates the **medial wall** of the femoral canal—a site notorious for strangulation[9] (**Fig. 2.13**).

Femoral Canal Contents

- Cloquet's (deep inguinal) lymph node.
- Lymphatics.
- Preperitoneal fat.

Because the femoral canal is so rigid, even a small protrusion of preperitoneal fat or sac can become trapped (**Fig. 2.14**).

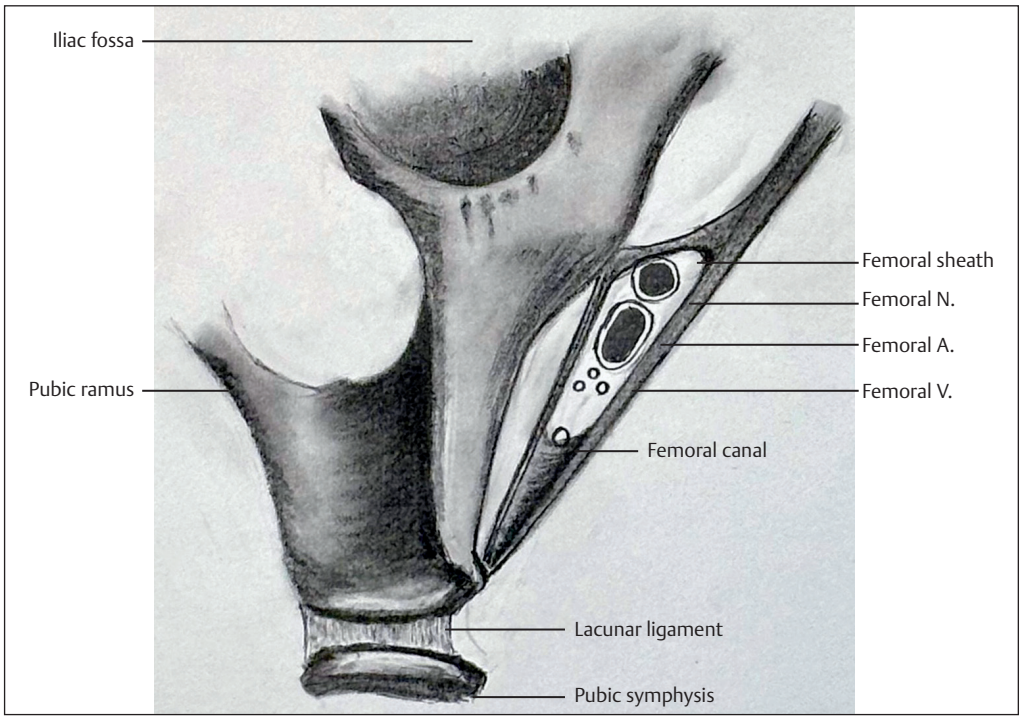


Fig. 2.13 Anatomy of the femoral canal and femoral ring. (Used with the permission of Juily Satam).

Table 2.5 Comparative anatomy and risk profile of groin hernia

Parameter	Indirect inguinal hernia	Direct inguinal hernia	Femoral hernia	Spigelian hernia	Obturator hernia
Location	Lateral to inferior epigastric vessels; enters via the deep inguinal ring and traverses the inguinal canal	Medial to inferior epigastric vessels; through Hesselbach's triangle	Below the inguinal ligament; medial to the femoral vein (femoral canal)	Along the semilunar line (Spigelian fascia), usually below the arcuate line	Through the obturator canal in the pelvis
Anatomic boundary/defect	Deep ring defect in transversalis fascia (TF)	Weakness of TF in Hesselbach's triangle	Femoral ring bounded by the lacunar ligament (medial), femoral vein (lateral), inguinal ligament (anterior), Cooper's ligament (posterior)	Defect in Spigelian aponeurosis between the rectus and lateral muscles	Obturator foramen covered by obturator membrane
Relation to the myopectineal orifice (MPO)	Lateral compartment of the MPO	Medial compartment of the MPO	Inferior compartment of the MPO	Outside the classical MPO but related to lateral abdominal wall weakness	Inferior pelvic extension of the MPO concept
Sac contents	Small bowel, omentum; occasionally the bladder or ovary (in females)	Usually the omentum; occasionally the bowel	Small bowel, omentum (tight neck)	Preperitoneal fat, omentum, small bowel	Small bowel (commonly the ileum)
Pathophysiology	Persistence of the processus vaginalis; congenital + acquired	Acquired weakness of TF	Narrow rigid canal predisposes to incarceration	Aponeurotic defect with the interparietal course	Pelvic floor weakness; more common in elderly females
Clinical presentation	Groin swelling extending to the scrotum; reducible	Medial groin bulge; rarely descends into the scrotum	Painful groin swelling below the ligament; often subtle	Lateral abdominal wall swelling; may be occult	Intermittent bowel obstruction; medial thigh pain (Howship–Romberg sign)
Strangulation risk	Moderate	Low	**High (most common strangulating groin hernia)**	Moderate–high (due to narrow fascial defect)	**Very high (often presents late)**
Surgical consideration	Sac reduction and deep ring closure; mesh repair	Reinforcement of the posterior wall (TF) with mesh	Urgent repair; careful dissection near the femoral vein	Often requires imaging for diagnosis; mesh repair	High mortality; early diagnosis is critical

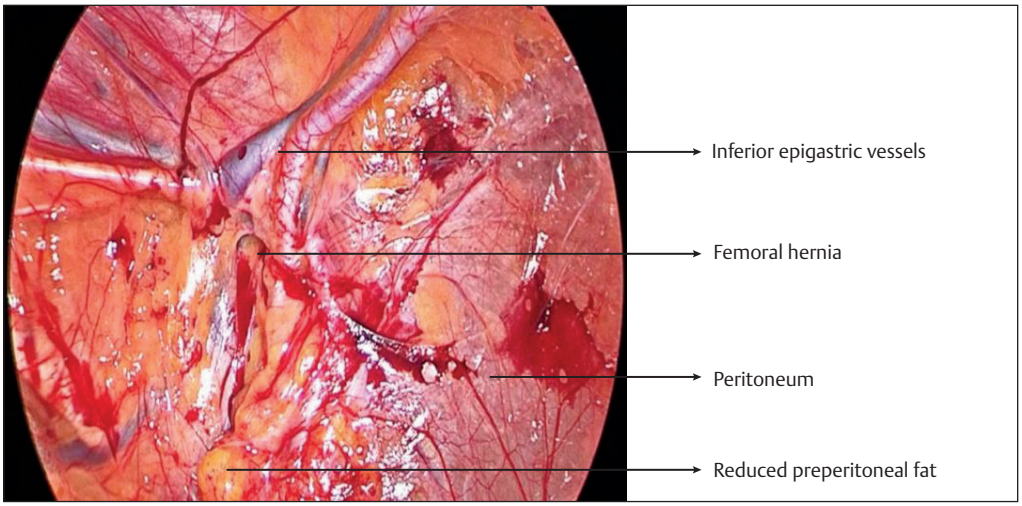


Fig. 2.14 Totally extraperitoneal (TEP) view of femoral hernia.

Why Femoral Hernias Strangulate

Chevrel and Wantz reported strangulation rates of up to 30 to 45%, the highest among all abdominal wall hernias.[8]

This is explained by the following:

- Fixed bony boundaries.
- Rigid medial lacunar ligament.
- Tight vascular relations with the femoral vein.
- Narrow neck that does not expand under pressure.

Surgical Relevance

- Must be inspected at every groin hernia operation—missed femoral defects account for a large proportion of "recurrences."
- In TAPP/TEP repair, the femoral canal is easily visualized from the posterior approach once Cooper's ligament is exposed.
- Mesh must extend inferiorly to cover the femoral space as part of complete MPO reinforcement.

Ventral Hernias

Ventral hernias encompass umbilical, paraumbilical, epigastric, and incisional types. Their frequency is strongly associated with fascial collagen composition, wound healing capacity, and IAP dynamics.

Umbilical and Paraumbilical Hernias

Embryologic Remnants

The umbilical region contains the following:

- Remnant of the **umbilical vein** → ligamentum teres.
- **Umbilical arteries** → medial umbilical ligaments.
- **Urachus** → median umbilical ligament.

These structures converge at the **umbilical cicatrix**, a natural weakness.[4]

Anatomic Features

Umbilical hernias in adults typically occur **adjacent to** the umbilical ring, often superiorly.

The rectus sheaths diverge at the umbilicus, leaving a small defect in the linea alba. Congenital failure of abdominal wall closure produces two distinct defects: omphalocele, a midline defect at the umbilical base in which herniated viscera remain covered by a membranous sac and which carries a high rate of associated anomalies, and gastroschisis, typically a right paraumbilical full-thickness defect without a covering sac and with a low rate of associated anomalies.[7]

Surgical Considerations

- The umbilical skin is tightly adherent—risk of devascularizing the stalk during dissection.
- For defects >1 to 2 cm, sublay (preperitoneal or retromuscular) mesh is preferred over primary closure (**Fig. 2.15**).

Epigastric Hernias

Origin

Epigastric hernias arise in the linea alba between the **xiphoid** and the **umbilicus**, typically through small gaps in the decussating fibers where neurovascular perforators penetrate.

Clinical Pathology

Most contain only **preperitoneal fat**, though sacs may enlarge with time. They tend to be multiple and vertically aligned.

Relevance for Surgeons

- Small defects are often underestimated; imaging[12] improves detection.
- Posterior approaches (robotic retrorectus) provide ideal mesh support.

Incisional Hernias

Incisional hernias arise from **fascial failure** after a previous laparotomy. The hallmark is **poor-quality scar tissue**, with altered collagen ratios. More than 10% of patients undergoing abdominal surgery develop an incisional hernia, accounting for over 150,000 incisional hernia repairs annually, with obesity, smoking, and steroid dependency among the principal risk factors.[7]

Collagen Biology

Klinge et al[13] demonstrated:

- Reduced **type I collagen.**
- Increased **type III collagen.**
- Disorganized fiber alignment.

These changes translate to reduced tensile strength and widening defects.

Loss of Domain

Loss of domain describes a condition in which a large percentage of abdominal contents have resided outside the cavity long enough to cause the following:

- Lateral retraction of the EO, IO, TA.

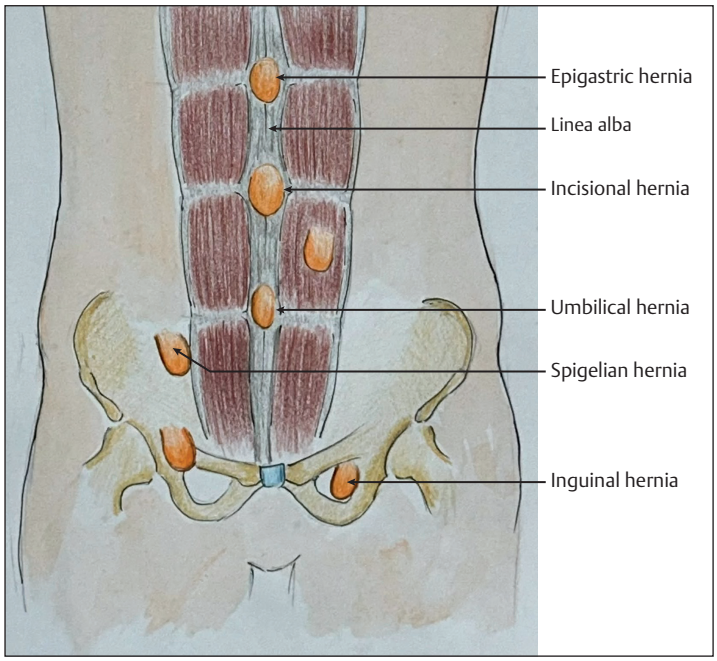


Fig. 2.15 Locations for anterior abdominal wall hernia. (Used with the permission of Juily Satam).

- Rectus diastasis.
- Contracted peritoneal sac.
- Reduced abdominal cavity volume.
- Elevated risk of postoperative abdominal compartment syndrome.

Radiologic quantification[12] assists in predicting whether botulinum toxin A, progressive pneumoperitoneum, or advanced component separation is necessary.

Flank and Pelvic Hernias

Spigelian Hernias

Anatomical Basis

The **Spigelian aponeurosis** is formed at the confluence of the IO and TA aponeuroses along the lateral edge of the rectus muscle at the **linea semilunaris**.

Most hernias occur at the following:

- *Below the arcuate line.*
- Where only TF and peritoneum form the posterior layer.
- Near the vascular perforator zone.

Clinical Features

Spigelian hernias are often interparietal, lying between muscle layers rather than protruding subcutaneously.

Surgical Application

- Laparoscopy/robotics provides superior visualization.
- Mesh is appropriately placed in the preperitoneal or retromuscular plane.

Lumbar Hernias

As Stumpf et al demonstrated, lumbar hernias occur at two triangles[14] (**Fig. 2.16**).

Superior Lumbar Triangle (Grynfeltt–Lesshaft)

Boundaries

- *Superior:* 12th rib + serratus posterior inferior.
- *Medial:* Erector spinae.
- *Lateral:* IO.
- *Floor:* TF.

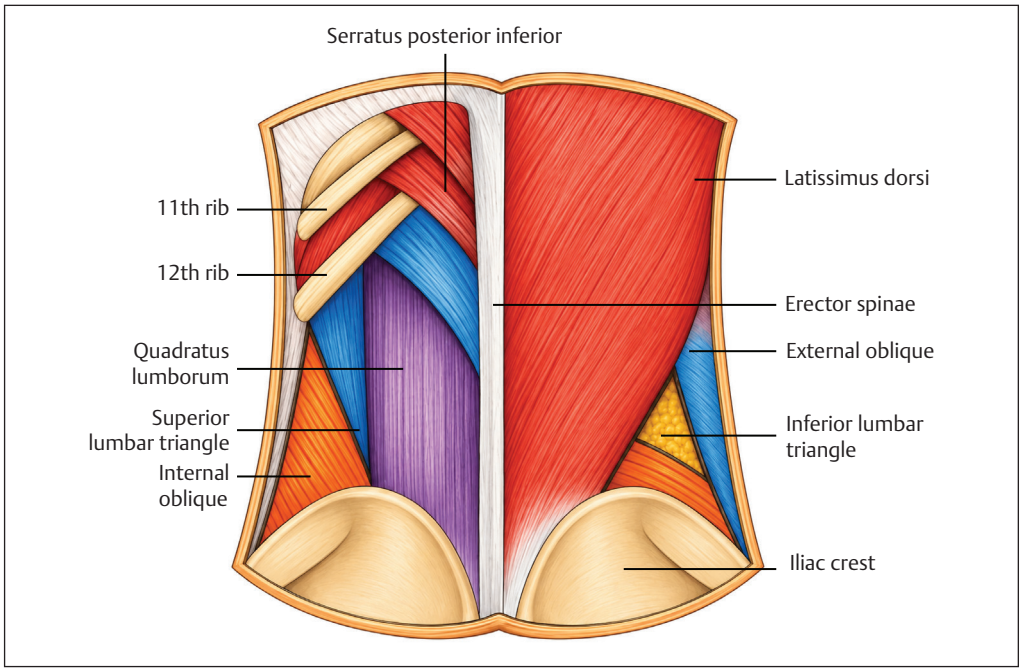


Fig. 2.16 Lumbar triangle.

Inferior Lumbar Triangle (Petit's Triangle)

Boundaries

- *Inferior:* Iliac crest.
- *Lateral:* Latissimus dorsi.
- *Anterior:* EO.

Surgical Relevance

- Posterior location risks bowel or renal involvement.
- Best repaired with **retromuscular** or **preperitoneal** mesh to avoid intraperitoneal contact.

Surgical Planes and Techniques

Introduction

Modern abdominal wall reconstruction depends entirely on an intimate understanding of the **fascial laminae**, **extraperitoneal compartments**, and **avascular planes** that allow safe dissection and wide prosthetic reinforcement.

The evolution from ACS (Ramírez) to posterior component separation (PCS; Novitsky's TAR) to robotic retromuscular reconstruction reflects a progressive exploitation of **natural myofascial planes** described by Stoppa, Chevrel, Flament, and Hellinger.[1,8]

Cross-sectional imaging[12] has further clarified the correct interpretation of these spaces, ensuring that surgeons respect the "true" retromuscular domain and avoid violating neurovascular zones.

Anatomy of Component Separation Techniques

Component separation refers to releasing the myofascial layers of the anterolateral abdominal wall to achieve midline closure in large ventral/incisional hernias.

Two major families exist:

- ACS.
- PCS.

PCS has largely replaced ACS in major reconstructions due to reduced wound morbidity.

Anterior Component Separation (Ramírez's Technique)

Developed in the 1990s, ACS involves releasing the **EO aponeurosis** lateral to the linea semilunaris.

Surgical Anatomy

- The EO aponeurosis is divided from the costal margin to the pubis, allowing medial advancement of the **IO + TA**.
- The neurovascular bundle between the IO and TA must be preserved.
- Dissection creates large **subcutaneous flaps**, risking skin ischemia.

Perfusion and Risk Zones

Saber et al demonstrated predictable vascular "safe zones" for anterior dissection. Excessive flap creation jeopardizes perforators and increases wound complications (**Fig. 2.17**).[10]

Limitations

- Lateral denervation risk.
- High seroma/wound complication rates.
- Limited posterior reinforcement.
- Because of these issues, ACS is now reserved for select cases where posterior planes are unavailable.

Posterior Component Separation: Transversus Abdominis Release

TAR, first described by Novitsky et al in 2012, revolutionized complex abdominal wall reconstruction.[15]

It creates a vast **bilateral retromuscular space**, allowing giant midline closures with tension-free mesh placement (**Fig. 2.18**).

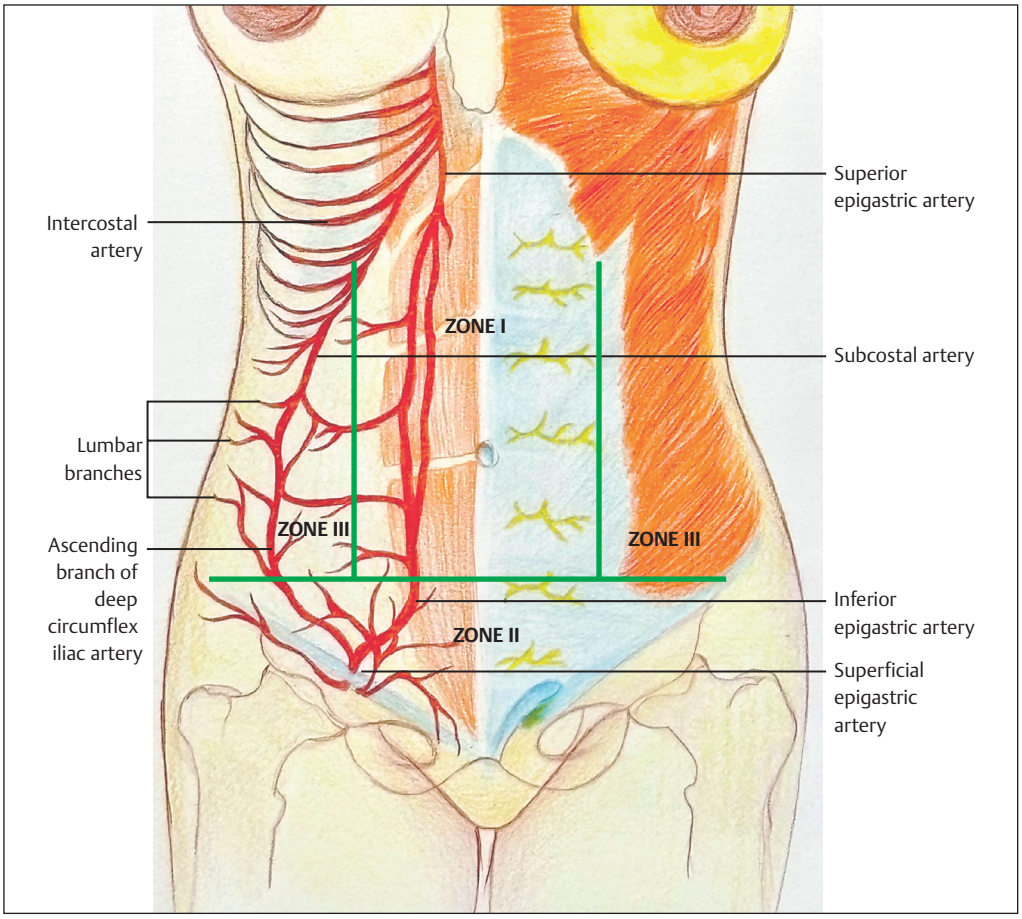


Fig. 2.17 Vascular zones and perfusion territories of the anterior abdominal wall relevant to component separation. (Used with the permission of Dhanashree S Kharche).

TAR: Anatomical Rationale

The posterior rectus sheath and its attachments serve as the plane of dissection.

Key Anatomical Principles

- The **retrorectus (Rives–Stoppa) space** is a native avascular compartment.
- The **TA muscle** inserts into the posterior rectus sheath above the **arcuate line**.
- Below the arcuate line, the posterior sheath disappears, and **rectus lies directly on the TF**.

TAR exploits the natural separation between the TA muscle and the TF, proving definitively that the TF is a distinct structural layer (as clarified by Asakage).[4]

TAR: Stepwise Anatomical Dissection (Fig. 2.18)

Step 1. Enter the Retrorectus Space

- Incise the posterior rectus sheath ~0.5 cm medial to its muscular border.
- Develop a plane medially to the linea alba and laterally to the semilunar line.

Step 2. Release the Transversus Abdominis Muscle

- At the semilunar line, TA fibers are visualized inserting onto the posterior sheath.
- The TA muscle is divided **longitudinally**, exposing the TF.

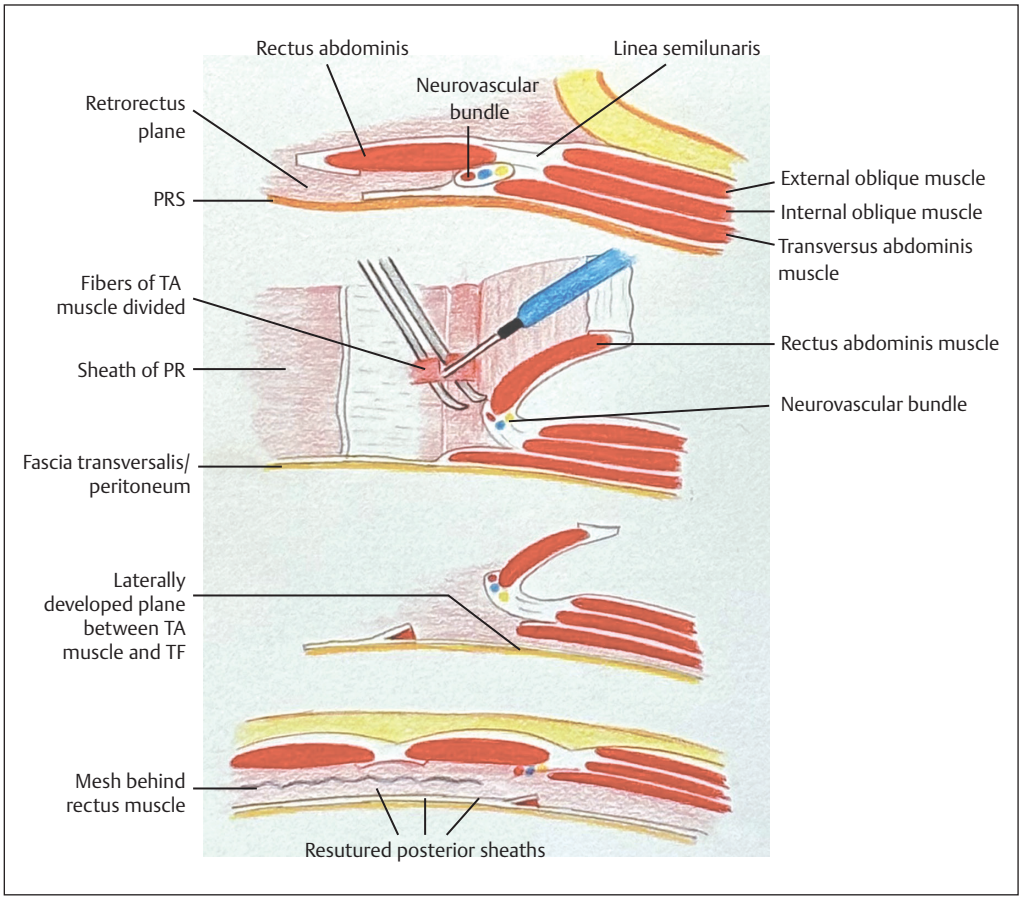


Fig. 2.18 Stepwise description of transversus abdominis release (TAR). PR, pyramidalis and rectus abdominis; PRS, posterior rectus sheath; TA, transverus abdominis; TF, transversalis fascia. (Used with the permission of Dhanashree S Kharche).

Step 3. Develop the Bilateral Pretransversalis Plane

Dissection proceeds laterally toward the **psoas**, **quadratus lumborum**, and **diaphragmatic slips**, forming one continuous compartment.

Step 4. Mesh Placement

A massive retromuscular prosthetic pocket is now available, extending from the:

- Xiphoid → space of Retzius.
- Semilunar line → psoas muscle.
- Costal margin → pubic symphysis.

This is the largest and safest mesh plane in abdominal reconstruction.

Rives–Stoppa Retromuscular Repair (Sublay Repair)

Stoppa recognized the preperitoneal/retromuscular plane as the ideal environment for mesh.

Key Principles

- Mesh is placed posterior to the rectus, anterior to the posterior sheath and TF.
- The posterior plane continuity allows for full coverage of the midline and MPO.

Recent literature confirms the retromuscular space as the gold standard for open ventral hernia repair due to minimal seroma, strong mesh incorporation, and reduced recurrence[8] (**Fig. 2.19**).

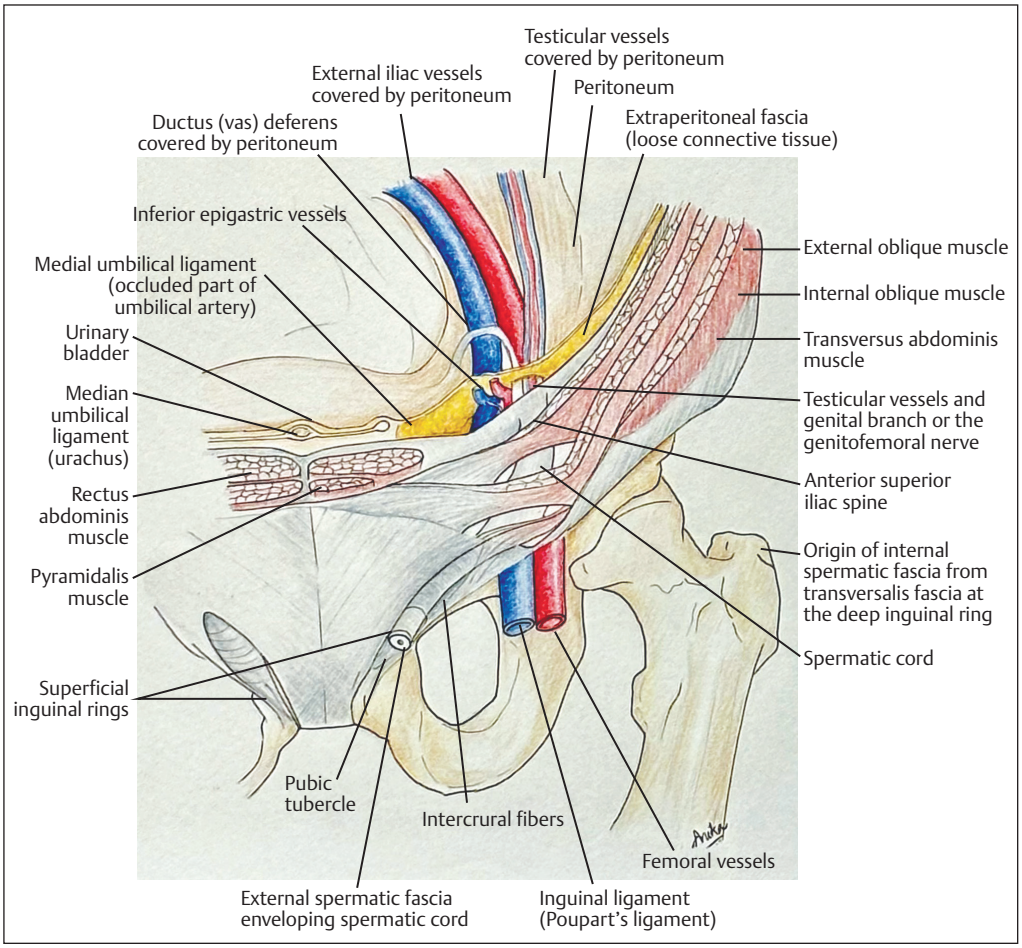


Fig. 2.19 Comprehensive posterior operative anatomy of the rectus sheath. (Used with the permission of Anika H Zaveri).

Laparoscopic and Robotic Planes

Totally Extraperitoneal Repair

TEP occurs entirely within the **preperitoneal/ extraperitoneal space**,[4] without entering the peritoneal cavity.

Anatomical Layers Traversed

- Skin.
- Subcutaneous tissue.
- Anterior rectus sheath.
- Rectus abdominis muscle (split).
- Posterior rectus sheath (above arcuate line only).
- TF.
- Preperitoneal space (Bogros + Retzius).

Key Surgical Landmarks

- IEVs.
- Deep ring.
- Pubic symphysis and Cooper's ligament.
- Iliopubic tract.
- Corona mortis (variable but critical).

Advantages

- Restores anatomy without violating peritoneum.
- Allows complete reinforcement of the MPO.

Transabdominal Preperitoneal Repair

TAPP enters the peritoneal cavity, then dissects the preperitoneal plane from above.

Unique Anatomical Perspectives

- Direct visualization of hernia sacs.
- Easy identification of femoral and obturator spaces.
- Complete dissection of the entire MPO before mesh placement.

Important Planes

- Peritoneum → preperitoneal areolar tissue.
- Dissection proceeds until Cooper's ligament, IEVs, vas, and gonadal vessels are exposed, achieving the **critical view of the MPO**.

Key Anatomical Concepts for Minimally Invasive Repair

Triangles

- **Triangle of doom:** Between the vas deferens and the gonadal vessels; contains external iliac vessels.
- **Triangle of pain:** Lateral to the gonadal vessels; contains the femoral branch of the genitofemoral nerve, lateral femoral cutaneous nerve (LFCN).
- **Corona mortis region:** Danger zone at the superior pubic ramus.

Safe Fixation Zones

- Cooper's ligament (medial).
- Rectus muscle/anterior abdominal wall (superior).
- Never fix mesh lateral to spermatic cord structures.

These guidelines derive strongly from laparoscopic cadaver work summarized by Rosenberger, Loeweneck, and Meyer.[16]

Physiological Role of Abdominal Muscles

The anterior abdominal wall is a dynamic, multilayered structure that serves multiple important functions. From superficial to deep, the layers include the skin, subcutaneous tissue, muscular layers (EO, IO, TA, and rectus abdominis), their aponeuroses, and the TF leading to the peritoneum.[17]

The muscles, fascia, tendons, spine, and the pelvic floor function with coordinated interactions to achieve the normal function of the abdominal wall. This helps in regulating the IAP, which is essential for the following:

- Breathing mechanics.
- Coughing.
- Defecation.
- Lifting.
- Trunk rotation and flexion.

The abdominal wall not only provides support for the contents of the abdominal cavity but also promotes core stability and dynamic control, which are fundamental for flexibility, synchronized body movements, and daily routine activities. The muscular framework of the anterior abdominal wall safeguards vital viscera and ensures their natural positioning and stable anatomical alignment. It provides a structural fortress that resists internal pressure.

When the integrity of the abdominal wall is compromised, like in a hernia, this support and structural stability are lost, producing consequences that go well beyond the appearance of a bulge. Hernias weaken the wall's ability to generate force, impairing posture, balance, and movements.[18] This leads not only to structural weakness but also to measurable impairments in muscle strength, posture, and quality of life. Hernias are not just a physical condition; they can also cause pain, discomfort, reduced physical activity, and gastrointestinal and urinary symptoms, as well as affect the mental and social well-being of the patient. If left untreated, they can worsen over time and lead to complications like incarceration, obstruction, and strangulation of the bowels.

Various studies have been done to ascertain the impact of hernia on abdominal wall function and compliance. A 2024 *BJS Open* study demonstrated that patients with incisional hernia have significantly reduced abdominal muscle strength compared with healthy controls, which affects their trunk flexion, core stability, and functional performance.[19] Understanding the anterior abdominal wall is therefore fundamental to hernia surgery, guiding both operative technique and postoperative rehabilitation. Thus, as a surgeon, it becomes very important and relevant to understand the type of muscles involved along with their physical, biochemical, and histological properties. Thus, a brief overview of the structure of various abdominal muscles is a prerequisite for all hernia surgeries.

The physiological properties of the muscle motor units are correlated with their histochemical characteristics in such a way that the phasic motor units (type II), which contract faster, are rich in glycogen but have a lower myoglobin content and hence appear pale(white) in color. They have further subtypes, as shown in **Table 2.6**. In contrast, the tonic motor fibers (type I) take a longer time to contract, have abundant oxidative enzymes and myoglobin content, are fatigue resistant, and appear dark (red).[20,21]

Out of these two types, muscles of the abdominal wall have a predominance of type I (slow) and type IIA (fast but moderately resistant to fatigue) fibers. The type IIB (fast fatigable) fibers are not completely absent, but their proportion is very limited, as seen from **Table 2.7**.[21,22] Thus, the main role of the abdominal wall musculature is to maintain continuous tonic support, provide structural stability, and maintain the intra-abdominal pressure. Sustained muscular tone helps prevent protrusion of intra-abdominal contents, especially during straining activities like coughing, defecation, lifting weights, etc. Any weakness or defect in them can lead to hernia formation. Comprehensive knowledge of abdominal muscle fiber architecture and distribution of fiber types is indispensable for appreciating and understanding their role in maintaining wall integrity. It is also relevant

Table 2.6 Features of the different types of muscle fibers

Characteristic	Type I (slow)	Type IIA (fast, resistant)	Type IIB (fast, fatigable)
Percentage	25–40%	Variable	Variable
Composition	Rich in mitochondria (red muscle)	Rich in myofibrils + moderate mitochondria	Rich in myofibrils (white muscle)
ATPase and glycolytic enzymes	–	++	++
Oxidative enzymes	++	+	–
Glycogen content	–	++	+++
Fibers per motor unit	Very few	Few	Many
Fatigue sensitivity	Very resistant	Moderately resistant	Highly sensitive
Contraction time	Long (58–110 ms)	Intermediate (30–55 ms)	Short (20–47 ms)

Table 2.7 Mean percentages of type I and type II fibers in the muscles of the abdominal wall

Distribution of different fiber types				
	Type I (%)	Type II (%)	Type IIA (%)	Type IIB (%)
Rectus abdominis	63–69	31–37	28	3
External oblique	52–54	46–48	40.9	5.1
Internal oblique	59–64	36–41	37.3	3.7
Transversus abdominis	60–68	32–40	37	3

for clinical assessment, optimizing surgical technique, and early patient recovery.

Rehabilitation of the core muscles after hernia repair is crucial to maintain muscle function and flexibility, as well as help reduce pain and improve quality of life. Structured rehabilitation programs are essential to restore muscle function, improve mobility, and reduce discomfort following hernia surgeries. An individualized stepwise approach, combining physical therapy with clinical guidance, is essential for early effective recovery, maximizing functional restoration and quality of life.

This is backed by clinical studies, which demonstrated that surgical repair improves anatomy, but rehabilitation is essential to restore full functional capacity.[23]

A systematic review was done by Brucchi et al assessing anterior wall function in the pre- and postoperative phase in patients with diastasis of the rectus muscles with or without abdominal wall hernia—de novo/incisional. The study used objective measures such as dynamometry, standardized physical tests, and/or patient-reported outcome measures (PROMs). The results stated that surgical reconstruction to restore the linea alba resulted in significant improvement. The trunk strength improved on dynamometry, clinical tests normalized, and PROMs showed meaningful gains in quality of life and disability.[24]

Editors' Note

"No disease of the human body, belonging to the province of the Surgeon, requires in its treatment a greater combination of accurate anatomic knowledge with surgical skill than hernia in all its varieties."

—Sir Astley Cooper

The role of anatomy in day-to-day clinical assessment, planning, and management is often underappreciated. Anatomy carries different perspectives for clinicians of different specialties. Most trainees and young surgeons often relegate understanding anatomy to an afterthought. They are not entirely to be blamed; they are expected to "know" but may not be guided to the right perspective.

Other surgical conditions often involve excision or resection of a diseased segment, and the outcomes are based on the extent of its excision. However, hernia is not just about resection of the hernial sac or contents. Previously, the prime focus of hernia surgery was to repair the defect and use mesh as a scaffold to reduce recurrences. Modern hernia surgery aims not only to control recurrence but also to enhance abdominal wall function, ultimately improving patients' quality of life.

Recognizing hernia to be a condition that needs application of accurate anatomical knowledge, without which it can profoundly affect a patient's abdominal wall function and quality of life, we would like the reader to appreciate anatomy from a fresh perspective. A perspective where grasp of anatomy is integral to clinical assessment, planning, treatment execution, and complication management while attempting to restore the functional strength of a hernia patient's abdominal wall and improve their quality of life. The evolution from the giant prosthetic reinforcement technique to component separation and the minimal access approach all came into existence as some surgeons have a different perspective of the same anatomy.

In this chapter, the authors have comprehensively covered anatomy from a surgeon's perspective while amalgamating it with the physiology of abdominal wall function. We hope the reader is able to realize this perspective, and integrating functional anatomy while reading the subsequent chapters would enable readers to develop a fresh perspective and empower them to make better decisions for their patients.

ERM, PKB

The Resolution

Scenario 1

Let us try to understand the perspective that we are talking about. Consider an average-built person being assessed for a groin hernia. Average-built individuals often have some fat in the lower abdomen, and it would be difficult to differentiate an inguinal from a femoral swelling by looking only at the skin folds and external appearance. Identifying the pubic tubercle and palpating the swelling in relation to this landmark would clinch the diagnosis. The inguinal sac is superomedial, while the femoral sac is inferolateral to the pubic tubercle. In cases where clinical suspicion persists, and radiological imaging is deemed necessary, contrast-enhanced CT (CECT) is the preferable investigation. **Fig. 2.20** shows the CECT imaging of the same patient. Recognizing the location of the defect in relation to the iliac/femoral vessels would help clinch the diagnosis.

As shown in **Fig. 2.20**, the *yellow arrow* marks the location of the hernial sac, whereas the *red arrow* demonstrates the femoral vessels. The hernia sac clearly emerges medial to the femoral vessels, pointing toward a femoral hernia. This patient previously underwent a Lichtenstein mesh repair performed for a femoral hernia misinterpreted as an inguinal hernia and hence had a recurrence.

Clinical Scenario

In this case, the error could have been avoided if the surgeons were in doubt; they could have chosen to perform a posterior preperitoneal repair, where a single procedure would have given easy access to inguinal, femoral, and even an obturator hernia, while an anterior approach would have been different and specific for each sac.

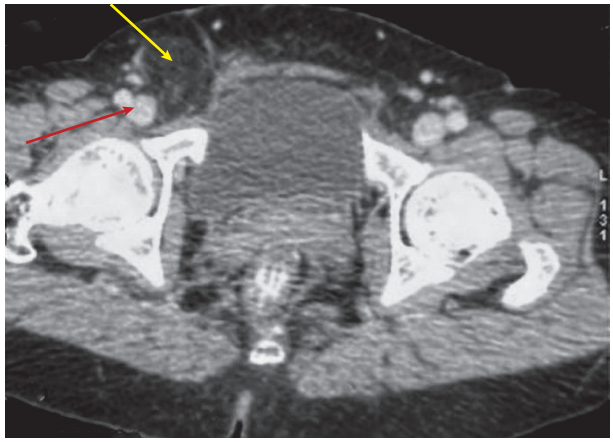


Fig. 2.20 Femoral hernia sac: The sac of a femoral hernia (*yellow arrow*) is seen emerging medial to the femoral/iliac vein (*red arrow*). CT, being objective, allows the images to be reviewed by anyone; we prefer it over USG or a Duplex scan. (Used with the permission of Dr Priyanka Kishore Bhagtani).

Clinical Scenario

Scenario 2

In this clinical scenario, there exist the following red flags:

- Chronic abdominal wound.
- Lack of sensation over the abdominal wall around the wound.

Fig. 2.1 demonstrates signs of vascular compromise. In the center of the wound, the dark red tissue appears to be the exposed bowel. The ulcer itself appears punched out with pale pink and dusky underlying muscle, with poor granulation, and the surrounding skin appears thin and dry; these are the signs of vascular compromise. Such complex situations warrant a multidisciplinary team approach.

Fig. 2.21 displays the wound being surrounded by an insensate area bound by black "X". The operative records of the previous procedure revealed the reason for this issue. It's quite likely that in the last procedure, neurovascular bundles were compromised or damaged in creating a flap to place a 20 × 20 cm onlay mesh, rendering the area susceptible to wound breakdown and poor healing.

Integrating the application of anatomical knowledge in the surgical strategy and situational awareness during the procedure can prevent such dreadful complications.

Radiological investigations such as CECT would be appropriate in such scenarios to assess the residual tissues better. Wound management would play an important role prior to considering further surgical options.



Fig. 2.21 Dermatome mapping of chronic abdominal wound: Within the area marked with a black "X", there is a complete lack of sensation of touch and pain. (Used with the permission of Dr Muhammed Nadeem Mehmood).

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