Pelvic neurovascular anatomy and avascular spaces: a pictorial essay of key surgical landmarks

İlker Selçuk[1], Koray Görkem Saçıntı[2], Stoyan Kostov[3], Mert Ocak[4], İlkan Tatar[5], Emre Huri[6], Hakan Raşit Yalçın[1]

[1]Clinic of Gynecologic Oncology, Ankara Bilkent City Hospital, Women's Health Education and Research Hospital, Ankara, Türkiye

[2]Department of Obstetrics, Gynecology and Reproductive Sciences, Yale School of Medicine, New Haven, CT, United States of America

[3]Gynecologic Oncology Research Institute, Medical University Pleven, Pleven, Bulgaria

[4]Department of Anatomy, Ankara University Faculty of Dentistry, Ankara, Türkiye

[5]Department of Anatomy, Hacettepe University Faculty of Medicine, Ankara, Türkiye

[6]Department of Urology, Hacettepe University Faculty of Medicine, Ankara, Türkiye

Abstract

A precise understanding of pelvic neurovascular anatomy is essential for minimizing complications during advanced gynecological and pelvic surgery. Retroperitoneal dissection requires a clear appreciation of spatial relationships between vascular, neural, and fascial structures. This pictorial essay provides an anatomically oriented overview of key pelvic compartments and pelvic avascular spaces, including the paraaortic, presacral, pararectal, paravesical, prevesical, and laterovascular spaces, through a curated series of our high-resolution intraoperative and cadaveric dissections. These illustrations emphasize surgical landmarks and neurovascular trajectories that are critical during radical hysterectomy, pelvic lymphadenectomy, deep endometriosis surgery, and other pelvic procedures. The anatomical content correlates with practical surgical applications, including the identification of danger zones, safe dissection planes, and routes for nerve-sparing techniques. Autonomic plexuses, somatic nerves, and vascular variants are also highlighted to support accurate and reproducible dissection. In particular, visual representations of the hypogastric nerve, pelvic splanchnic nerves, and inferior hypogastric plexus aid understanding of the pelvic autonomic pathways involved in continence and sexual function. The presented illustrations offer an operative roadmap that supports surgical planning, enhances intraoperative orientation, and promotes the preservation of neurovascular integrity. This visual anatomical reference aims to improve both surgical safety and functional outcomes in advanced gynecological procedures. [J Turk Ger Gynecol Assoc. 2026; 27(2): 125-46]

Keywords: Neuropelviology, hypogastric nerve, nerve-sparing, pelvic avascular spaces, internal iliac artery

Received: February 24, 2026 **Accepted:** May 5, 2026 **Publication Date:** June 02, 2026

Introduction

The pelvic cavity is enclosed by the pelvic bones on the outside, while the parietal peritoneum internally covers the abdominopelvic cavity. The space beyond this layer is called the extraperitoneal space, comprising predominantly fatty connective tissue and loose areolar tissue with potential surgical spaces and planes. The anatomical compartments within the extraperitoneal space include the retroperitoneal, subperitoneal, and preperitoneal spaces. Among these, the term "retroperitoneum" refers specifically to the space located posterior to the parietal peritoneum. Therefore, all potential spaces posterior to the parietal peritoneum, extending from the diaphragm cranially to the pelvic floor muscles (levator ani, coccygeus) caudally, can be defined as the retroperitoneum. These compartments contain essential anatomical structures,

Address for Correspondence: *İlker Selçuk*
e-mail: *ilkerselcukmd@hotmail.com* ***ORCID:*** *orcid.org/0000-0003-0499-5722*

DOI: *10.4274/jtgga.galenos.2026.2026-2-14*

Cite this article as: *Selçuk İ, Saçıntı KG, Kostov S, Ocak M, Tatar İ, Huri E, et al. Pelvic neurovascular anatomy and avascular spaces: a pictorial essay of key surgical landmarks. J Turk Ger Gynecol Assoc. 2026; 27(2): 125-46*

such as the ureter, major blood vessels, autonomic nerves, and the parametrium, and are of high importance in pelvic (gynecological) surgery. The parametrium is a densely organized area incorporating critical neurovascular and lymphatic pathways, which are often encountered during deep pelvic dissection.

What does this study add to the literature?

This pictorial essay delineates the pertinent surgical anatomy of these pelvic avascular spaces and key retroperitoneal structures through images obtained via laparoscopic, open surgical, and cadaveric dissection techniques. It emphasizes their significance and use in surgical procedures to optimize exposure, ensure safe dissection, and preserve neurovascular integrity during radical pelvic surgery.

Application of the retroperitoneal spaces in surgical practice

Incising the parietal peritoneum in the abdomen guides dissection toward the retroperitoneal spaces. Figure 1 shows the entrance to the retroperitoneal area, especially for the dissection of the pararectal and paravesical spaces. The paraaortic, presacral, pararectal, paravesical, prevesical spaces, and laterovascular plane maintain integrity.

Paraaortic space

Dissection of the posterior parietal peritoneum between the root of the mesentery and the mesentery of the sigmoid colon exposes the aorta and inferior vena cava, along with the surrounding lumbo-aortic lymph nodes. The space extends cranially from the diaphragm to the aortic bifurcation at the lumbar (L) 4-5 vertebral level.

Further dissection of the peritoneum in the sub-duodenal area and craniolateral mobilization of the horizontal part of the duodenum toward the right side reveal the renal vessels. The right ureter is typically attached to the posteromedial side of the ascending colon, and the ovarian vessels are located medial to the ureter. On the left, the ureter lies posterior to the sigmoid mesentery, also with the ovarian vessels medial to it. An intraoperative image highlighting the paraaortic space is presented in Figure 2.

Borders

- Median-central: Abdominal aorta (left), inferior vena cava (right).
- Lateral: Psoas major muscle and ureters bilaterally.
- Posterior: Anterior longitudinal ligament and L vertebrae.
- Anterior: Posterior parietal peritoneum.

Contents

Paraaortic lymph nodes, intermesenteric plexus, superior hypogastric plexus, sympathetic chain, L plexus nerves, and cisterna chyli.

Surgical relevance

Paraaortic lymphadenectomy, nerve-sparing paraaortic lymphadenectomy, aorto-iliac operations.

Presacral space

Dissection of the presacral space is initiated by incising the peritoneum adjacent to the sigmoid colon at the level of the sacral promontory. The retrorectal space is another term used to describe this area. The lateral border of the promontory serves as a landmark point for the pelvic brim, where vessels, nerves, and the ureter run toward the pelvis. The presacral space and its relationship to adjacent neurovascular structures and the rectosigmoid colon are illustrated in the intraoperative image shown in Figure 3.

Borders

Anterior: Visceral fascia of the rectum (mesorectal fascia)
Posterior: Presacral parietal fascia (overlying the sacrum)
Lateral: Common iliac arteries and ureters.

Contents

Hypogastric nerves, presacral veins.

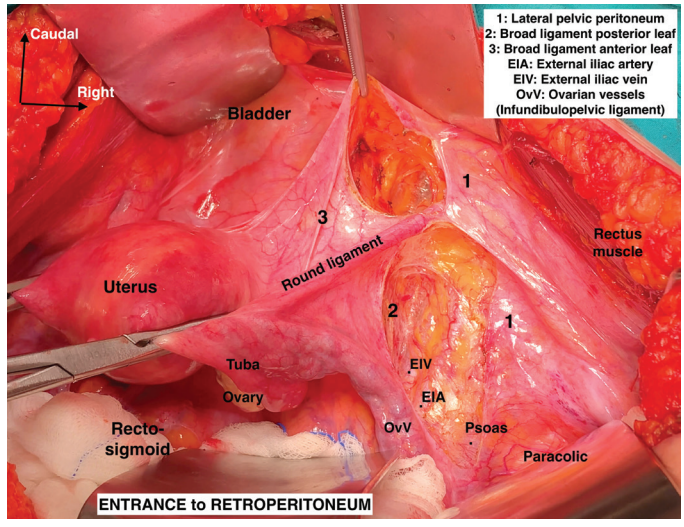

Figure 1. Entrance to the retroperitoneal area. [all surgical and cadaveric dissections were performed by the author (Dr. İlker Selçuk) and his team]

Surgical relevance

The presacral space is crucial for mobilizing and excising the rectosigmoid colon, performing radical pelvic surgeries (1), nerve-sparing techniques, and sacrocolpopexy procedures.

Pararectal and paravesical space

The pararectal and paravesical spaces are key surgico-anatomical areas in the pelvis, important in gynecological, colorectal, and urological procedures. Recognizing the landmarks and contents is essential for deep pelvic operations. Incision of the lateral pelvic peritoneum, along the lateral extension of the broad ligament, lateral to the rectum and bladder, exposes the dissection planes for the pararectal and paravesical spaces in the posterolateral and anterolateral regions of the pelvis, respectively. Intraoperative images demonstrating the anatomical boundaries and surgical exposure of the pararectal and paravesical spaces, including adjacent vascular and neural structures, are shown in Figures 4 and 5.

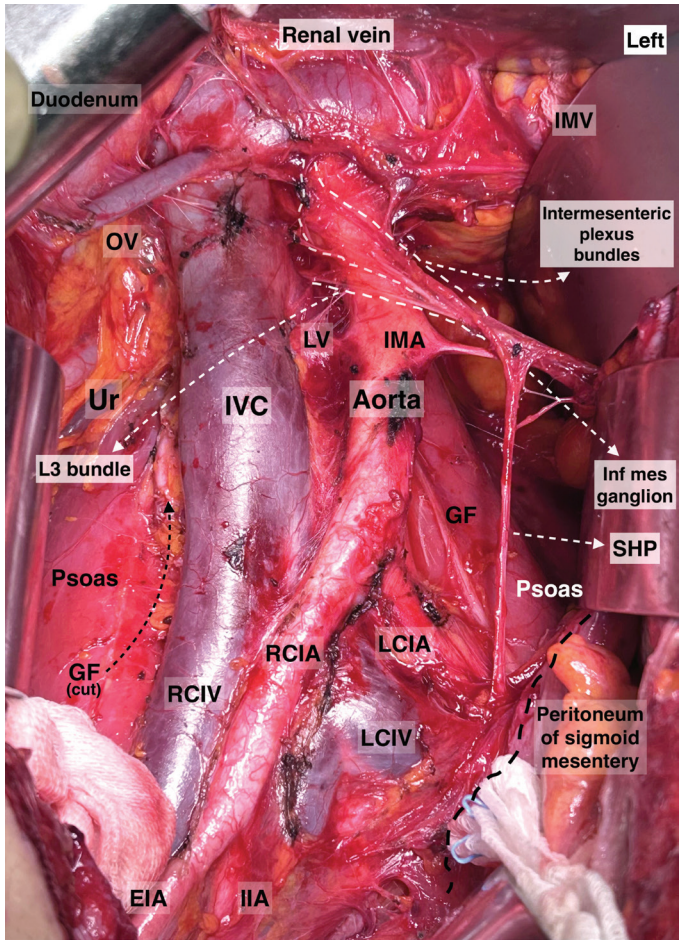

Figure 2. Paraaortic space and components
IVC: Inferior vena cava, RCIA: Right common iliac artery, RCIV: Right common iliac vein, LCIA: Left common iliac artery, LCIV: Left common iliac vein, EIA: External iliac artery, IIA: Internal iliac artery, IMA: Inferior mesenteric artery, IMV: Inferior mesenteric vein, OV: Ovarian vein, LV: Lumbar vein, Ur: Ureter, GF: Genitofemoral nerve, SHP: Superior hypogastric plexus, L: Lumbar, Inf mes: Inferior mesenteric

Pararectal space

The pararectal space is a potential anatomical compartment located bilaterally alongside the rectum. Upon dissection and mobilization of the ureter from the broad ligament posterior leaf, the space is divided into two distinct compartments: the medial pararectal space (Okabayashi) and the lateral pararectal space (Latzko) (2). The ureter lies within the same fascial sheet as the hypogastric nerve, commonly referred to as the ureterohypogastric fascia. Anatomically, the pararectal space represents a continuation of the presacral space. Figure 6 presents an intraoperative view of the pararectal space, clearly demonstrating its relationship to adjacent vascular and neural structures, including the ureter and internal iliac vessels.

Borders

Lateral: Internal iliac artery and associated veins.

Medial: Rectum or mesorectum, ureter, and rectouterine ligament (uterosacral ligament).

Anterior: Parauterine and paracervix tissue with the uterine artery and vein (cardinal ligament).

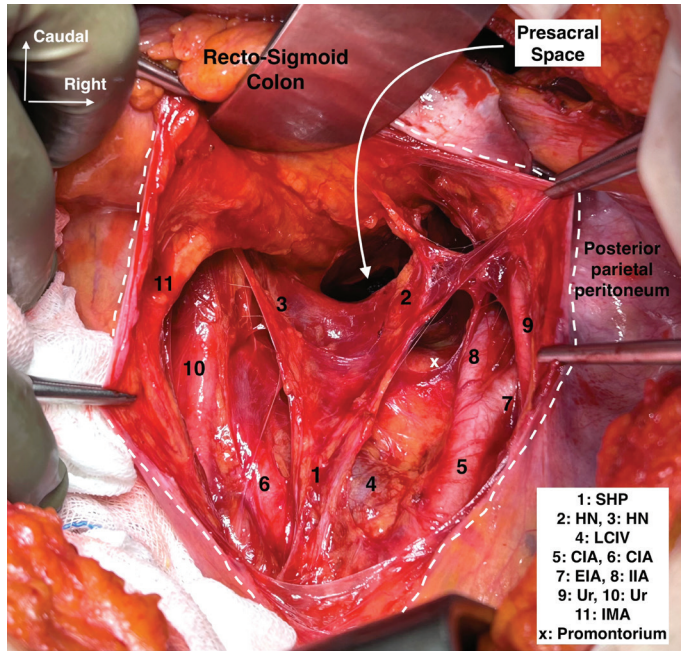

Figure 3. Presacral (retrorectal) space
SHP: Superior hypogastric plexus, HN: Hypogastric nerve, LCIV: Left common iliac vein, CIA: Common iliac artery, EIA: External iliac artery, IIA: Internal iliac artery, Ur: Ureter, IMA: Inferior mesenteric artery

Posterior: Sacrum and presacral fascia.
Inferior: Pelvic floor, levator ani (mainly iliococcygeus).
Superior: Peritoneal reflection of the parietal peritoneum extending toward the lateral pelvic wall.

Contents

Hypogastric nerve, pelvic splanchnic nerves, inferior hypogastric plexus, and middle rectal artery.

Surgical relevance

Radical pelvic surgery, lateral and dorsal parametrectomy, nerve-sparing applications, internal iliac artery ligation, uterine artery ligation, ureteral mobilization, deep endometriosis surgery, and rectal resections.
The pararectal space is the most critical region when performing nerve-sparing pelvic procedures, as it allows the surgeon to identify the pelvic autonomic nerves. However, this is the initial step in nerve-sparing surgery; subsequent efforts focus on preserving the target branches during ongoing surgical maneuvers.

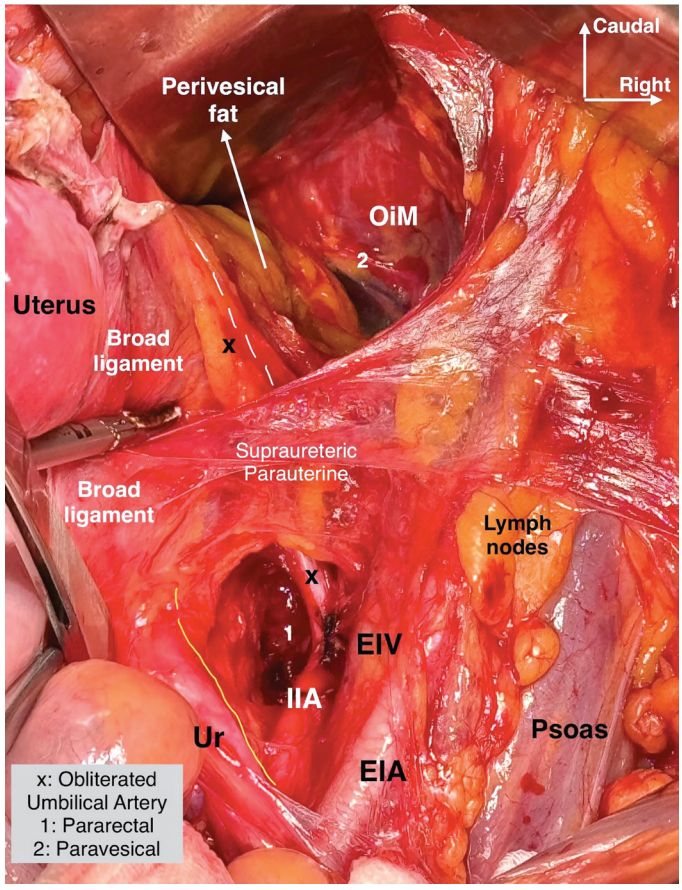

Figure 4. Lateral spaces of the pelvis, surgical landmarks for the paravesical and pararectal spaces
EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, Ur: Ureter, OiM: Obturator internus muscle

Paravesical space

The paravesical space is a potential compartment located bilaterally between the bladder and the pelvic sidewall. The obliterated umbilical artery lies attached to the perivesical fatty tissue and forms a fascial sheet, known as the umbilicovesical fascia. Dissection and mobilization of the obliterated umbilical artery divides the space into the medial and lateral paravesical spaces. Figure 7 displays an intraoperative view of the paravesical space, illustrating its dissection planes and anatomical relationships with key vascular and neural structures.

Borders

Lateral: Pelvic sidewall, caudal part of the external iliac vessels, obturator internus muscle, and obturator neurovascular bundle
Medial: Urinary bladder, visceral fascia of the bladder, obliterated umbilical artery, superior vesical artery.
Anterior: Pubic bone, superior pubic ramus.
Posterior: Parauterine and paracervix tissue with the uterine artery and vein (Cardinal ligament).

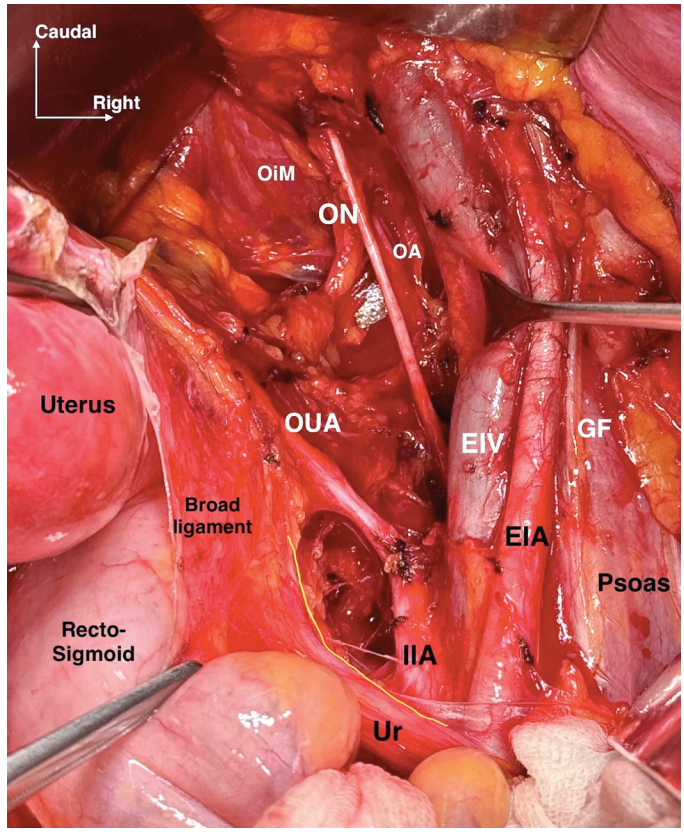

Figure 5. The paravesical and pararectal space
GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, Ur: Ureter, OUA: Obliterated umbilical artery, ON: Obturator nerve, OA: Obturator artery, OiM: Obturator internus muscle

Inferior: Pelvic floor, levator ani (mainly pubococcygeus).
Inferolateral: Tendinous arch of levator ani.
Superior: Peritoneal reflection of the parietal peritoneum extending over the bladder.

Contents

Obturator nerve, artery, and vein, pelvic lymph nodes, superior vesical artery, bladder nerve branches of the inferior hypogastric plexus, pubic anastomotic vessels (corona mortis vessels).

Surgical relevance

Radical hysterectomy, lateral and ventral parametrectomy, pelvic lymphadenectomy, ureteric dissection, urogynecological procedures, and bladder surgeries.

Prevesical space

The prevesical space lies between the bladder and the pubic bone and allows the bladder to expand. This potential space permits expansion of the bladder and serves as an essential surgical corridor in urogynecological procedures, such as pectineal or Cooper's ligament fixation procedures (3). Dissection begins by incising the peritoneum overlying the bladder dome, posterior to the pubic bone, and continuing anterior to the bladder. The prevesical and paravesical spaces are contiguous, forming a continuous dissection plane. Figure 8 shows a surgical view of the prevesical space, demonstrating its anterior location and continuity with the paravesical compartment, as well as its relevance in procedures involving the bladder neck and urethra.

Borders

Anterior: Pubic symphysis and posterior surface of the pubic bone
Posterior: Anterior surface of the bladder.
Lateral: Obliterated umbilical artery.
Inferior: Pelvic floor, levator ani, and pubocervical fascia.
Inferolateral: Tendinous arch of the pelvic fascia.
Superior: Peritoneal reflection over the bladder (continuous with the anterior leaf of the broad ligament).

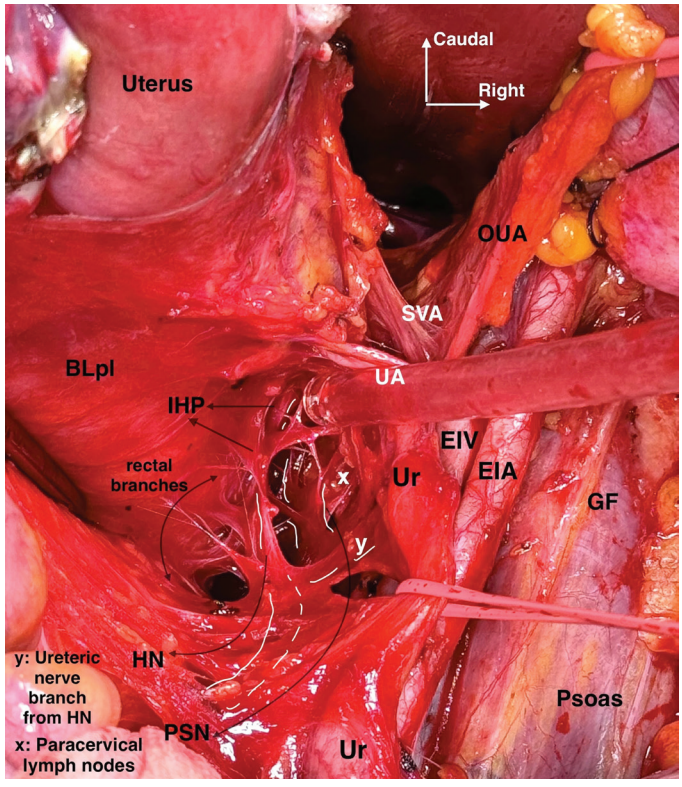

Figure 6. The pararectal space and its components after dissection and lateralization of the ureter from the broad ligament posterior leaf, exposing the medial pararectal approach
GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, Ur: Ureter, OUA: Obliterated umbilical artery, SVA: Superior vesical artery, UA: Uterine artery, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, BLpl: Broad ligament posterior leaf

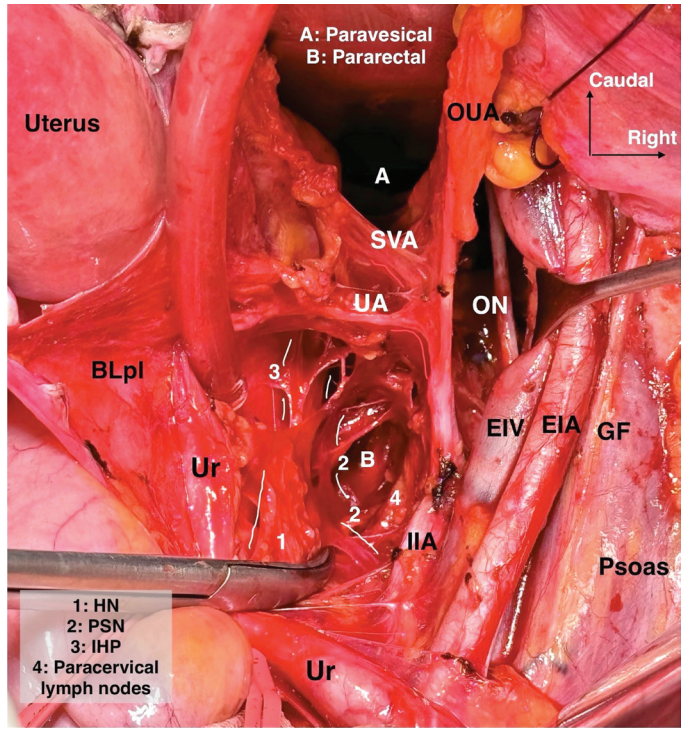

Figure 7. Medial and lateral paravesical space with the pararectal space
GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, ON: Obturator nerve, IIA: Internal iliac artery, OUA: Obliterated umbilical artery, SVA: Superior vesical artery, UA: Uterine artery, Ur: Ureter, BLpl: Broad ligament posterior leaf, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves

Contents

Pubovesical ligament, pubourethral ligament, dorsal vessels of the clitoris, urethra, and prevesical venous plexus.

Surgical relevance

Access to the urethra, anterior vaginal wall, and bladder base; mid-urethral sling procedure (e.g., transvaginal tape); bladder suspension procedure (e.g., Burch colposuspension); and bladder resection procedures.

Laterovascular plane (medial psoas space)

The laterovascular plane, also referred to as the medial psoas space, is accessed by dissecting and medially mobilizing the external iliac vessels away from the psoas major muscle. This dissection reveals a deep anatomical plane critical for advanced pelvic surgery.

Within this anatomical region lie the paracervical and deep common iliac lymph nodes, which are frequently targeted during oncological procedures. The obturator nerve is typically identified in the superficial compartment where it emerges from the psoas major muscle. Inferomedial to the obturator nerve and psoas major muscle, the lumbosacral trunk can be observed on the lateral side of the internal iliac vein (4). The greater sciatic notch is a significant anatomical landmark located laterally to the lumbosacral trunk. Figure 9 illustrates a detailed surgical dissection of the laterovascular plane, emphasizing the spatial relationships between the external iliac vessels, obturator nerve, and lumbosacral trunk, relative to the psoas major muscle.

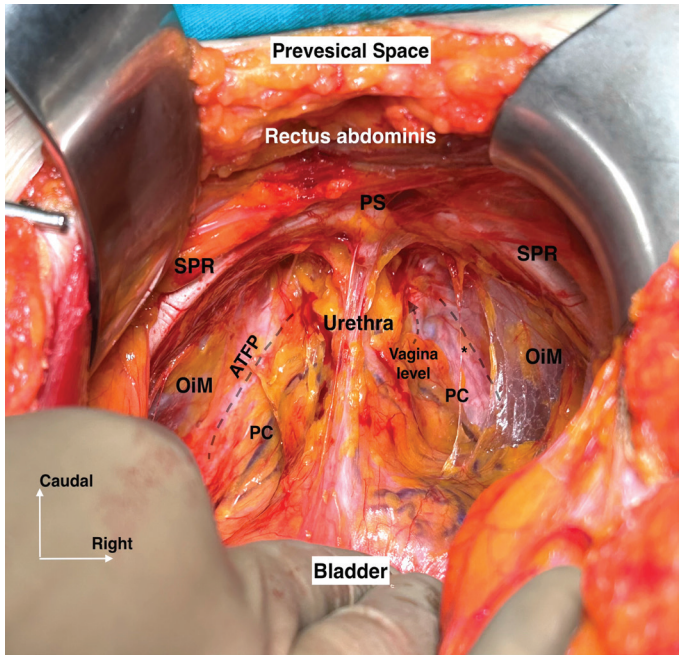

Figure 8. Prevesical space
PS: Pubic symphysis, SPR: Superior pubic ramus, OiM: Obturator internus muscle, PC: Pubococcygeus, ATFP: Arcus tendineus fascia pelvis

Surgical relevance

The laterovascular plane is a crucial access route in laterally extended parametrectomy, deep infiltrating endometriosis surgery, and pelvic or paracervical lymphadenectomy. Clear identification of neurovascular structures within this space is essential to avoid complications and ensure complete resection during oncological procedures.

How to apply this anatomical knowledge to difficult pelvic surgery?

When the pelvic anatomy is distorted, the retroperitoneal route enhances the precision of surgical maneuvers. The sacral promontory on the posterior aspect may be used to identify the entry to the pelvic cavity (pelvic brim) and facilitates further identification of critical anatomical structures for meticulous dissection and safe surgical procedures, including the ureter, common iliac artery, and/or superior hypogastric plexus. Anteriorly, the pubic bone and its superior portion can be similarly used to identify the prevesical and paravesical spaces. Laterally, the round ligament or the psoas major muscle provides the dissection plane for the external iliac

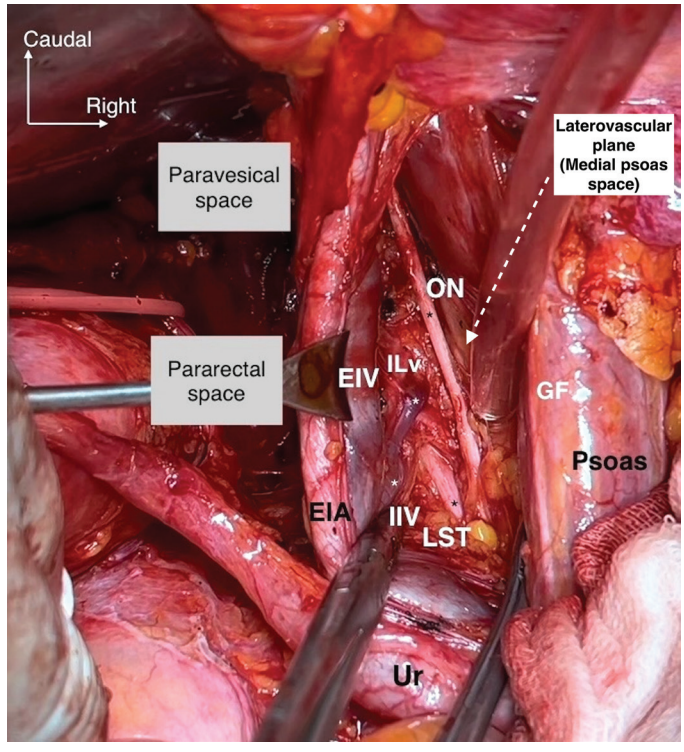

Figure 9. Laterovascular plane (medial psoas space)
GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, ON: Obturator nerve, LST: Lumbosacral trunk, IIV: Internal iliac vein, ILv: Iliolumbar vein, Ur: Ureter

vessels, as well as the paravesical and pararectal spaces. Since all the pelvic avascular spaces are continuous (presacral, pararectal, paravesical, and prevesical), once one space is encountered, the adjacent spaces can also be developed.

Pelvic neurovascular anatomy

Retroperitoneal vascularization

The abdominal aorta delivers arterial blood to the abdominopelvic structures, while venous return ultimately drains into the inferior vena cava. The vascular components of the abdominopelvic cavity are primarily located in the retroperitoneal space. Upon incising the posterior parietal peritoneum of the posterior abdominal wall, between the root of the mesentery and the sigmoid mesocolon, the fatty and lymphoid tissues overlying the aorta and inferior vena cava become visible. In the pelvis, incising the pelvic peritoneum lateral to the visceral organs reveals the pelvic vessels.

Arterial system

Abdominal aorta

The aorta enters the abdominal cavity at the level of the thoracic (T) 12th vertebra, between the crura of the diaphragm, and is referred to as the abdominal aorta. The abdominal aorta bifurcates into the right and left common iliac arteries at the level of the L 4th vertebra, known as the aortic bifurcation. This area is approximately at the superposed level of the umbilicus. The abdominal aorta lies anterior to the L vertebrae and the anterior longitudinal ligament, on the left side of the midline, left to the inferior vena cava (Figure 2).

Major branches of the abdominal aorta

a. Single visceral branches (anterior/antero-lateral origin):
   1. Celiac trunk (upper L1 vertebra level)
   2. Superior mesenteric artery (mid L1 vertebra level, between the celiac trunk and renal arteries)
   3. Inferior mesenteric artery (L3 vertebra level, anterolateral origin)
b. Double visceral branches (lateral origin):
   1. Middle suprarenal arteries (lower L1 vertebra level)
   2. Renal arteries (L1-L2 vertebra level)
   3. Ovarian arteries (L2 vertebra level)
c. Parietal branches
   1. Inferior phrenic arteries (T12 vertebra level)
   2. L arteries (L1-L4 vertebrae level, from the posterolateral surface)
   3. Median sacral artery, at the L4 vertebra level, as the terminal branch of the abdominal aorta, arises from the posterior surface.

Common iliac arteries

The abdominal aorta divides into the right and left common iliac arteries at the level of the L4 vertebra. The common iliac arteries lie caudolaterally on the lateral sides of the L5 vertebra and are medial to the psoas major muscle. The right common iliac artery crosses superior to the confluence of the inferior vena cava. It is slightly longer than the left common iliac artery because the aortic bifurcation occurs on the left side.

Between the right and left common iliac artery, the left common iliac vein lies obliquely toward the left caudal side at the upper part of the presacral space. The left common iliac artery is positioned anterolateral to the left common iliac vein. Anterior to the left common iliac vein is the superior hypogastric plexus, while the sympathetic trunk is situated posterior to the left common iliac artery.

Both ureters cross superior to the distal part of the common iliac arteries. On the right side, the crossing of the ureter may shift toward the beginning of the external iliac artery. Common iliac arteries divide into the external and internal iliac arteries anterior to the sacroiliac joint, at the level of the L5-sacral (S) 1st intervertebral disc, where the iliac bifurcation occurs.

Surgical relevance

Numerous renovascular variations, venous or arterial, may be encountered within the paraaortic space. Arterial variations may appear as accessory arteries or as main renal arteries with a low origin or low-lying attitude. On the left side, such variations predominantly arise from the supramesenteric lateral aspect of the aorta, whereas on the right, they may also originate from the interaortocaval area (Figure 10).

External iliac artery

The external iliac artery represents the longitudinal continuation of the common iliac artery, located at the medial superior edge of the psoas major muscle (Figure 11). Lateral to the external iliac artery, the genitofemoral nerve is found on the anterior surface of the psoas major. Upon passing posterior to the inguinal ligament (posterior in anatomical position, which appears inferior in the surgical supine position), it continues as the femoral artery within the femoral triangle.

Major branches of the external iliac artery include:

1. Inferior epigastric artery
2. Deep circumflex iliac artery

Surgical relevance

Importantly, no vascular structures are typically encountered at the 12 o'clock position relative to the external iliac artery. Therefore, lymphadenectomy dissection planes that run

parallel to the artery in this zone are generally considered safe and pose minimal risk of vascular injury.

Inferior epigastric artery

The inferior epigastric artery originates from the caudal anteromedial edge of the external iliac artery at the posterior side of the inguinal ligament. It runs obliquely medial, anterior to the peritoneum and posterior to the rectus abdominis muscle. The inferior epigastric artery and the surrounding peritoneum at the posterior part of the anterior abdominal wall form the lateral umbilical fold. The inferior epigastric artery supplies the lower deep medial part of the anterior abdominal wall.

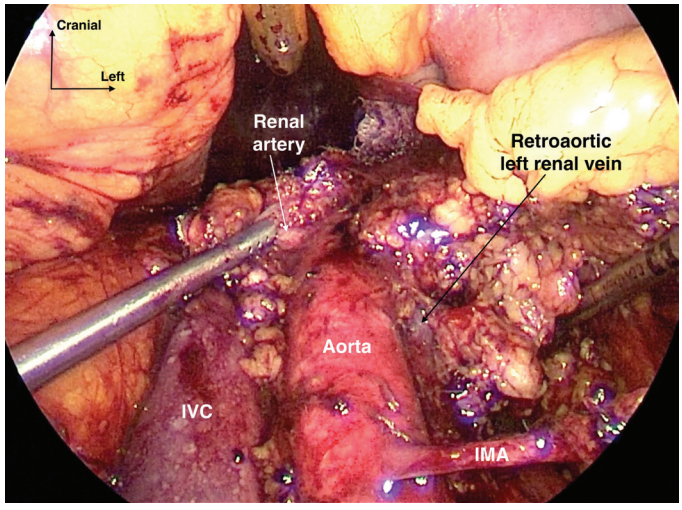

Figure 10. Renovascular variation at the paraaortic area, retroaortic left renal vein and the right renal artery is arising from a low level, detected during inter-aortocaval dissection
IMA: Inferior mesenteric artery, IVC: Inferior vena cava

Surgical relevance

The inferior epigastric artery may give rise to the pubic anastomotic artery and contribute to the arterial corona mortis. This can be observed on the lateral part of the superior pubic ramus, at the posterior aspect of the pectineal ligament. Additionally, during secondary trocar insertions in laparoscopic pelvic procedures, the reflection of the inferior epigastric artery should be identified via the abdominal exposure of the posterior side of the anterior abdominal wall by the laparoscopic camera.

Deep circumflex iliac artery

The deep circumflex iliac artery originates from the caudal anterolateral end of the external iliac artery on the posterior side of the inguinal ligament, proximal to the origin of the inferior epigastric artery. It runs parallel to the inguinal ligament and anastomoses with the superior gluteal artery over the iliac crest. The deep circumflex iliac artery supplies the lower deep lateral part of the anterior abdominal wall.

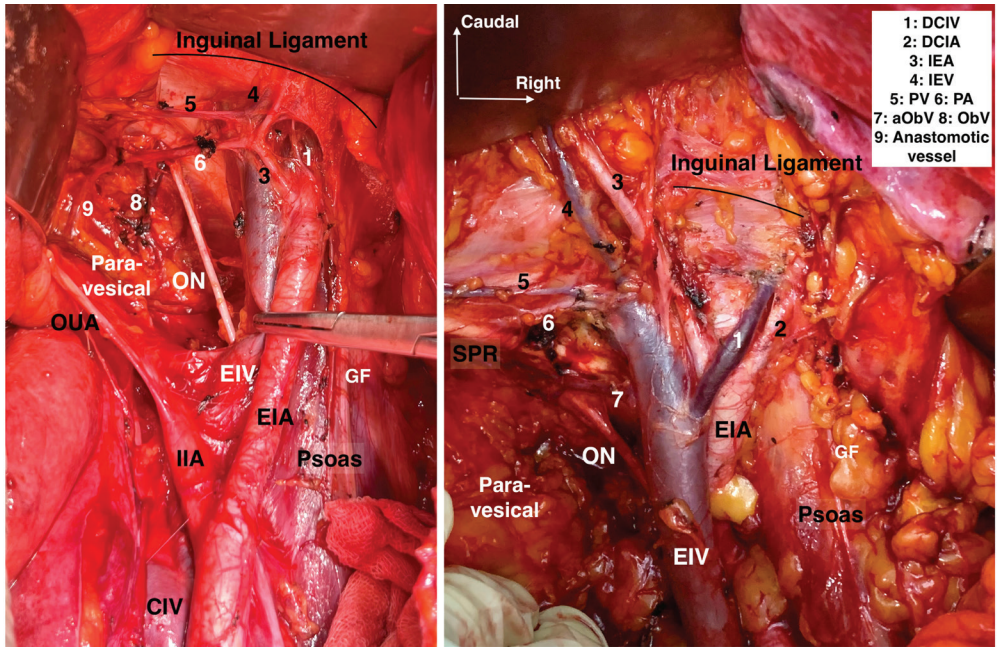

Figure 11. Branches of the external iliac artery and tributaries of the external iliac vein, with the Corona Mortis anastomotic vessels
GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, CIV: Common iliac vein, OUA: Obliterated umbilical artery, ON: Obturator nerve, ObV: Obturator vein, aObV: Aberrant obturator vein, PA: Pubic artery, PV: Pubic vein, SPR: Superior pubic ramus, IEA: Inferior epigastric artery, IEV: Inferior epigastric vein, DCIA: Deep circumflex iliac artery, DCIV: Deep circumflex iliac vein

Internal iliac artery

After the iliac bifurcation, the inferomedial (posterior in anatomical position and inferior in surgical supine position) branch of the common iliac artery in the pelvis is the internal iliac artery. The internal iliac artery lies inferolateral to the ureter at the lateral edge of the pararectal space. It courses downward into the pelvis, supplying the pelvic viscera and parietal structures. It divides into anterior and posterior trunks with many branches at the upper part of the greater sciatic foramen. The branching pattern of the internal iliac artery varies. Figure 12 illustrates a cadaveric dissection of the right hemipelvis, demonstrating the internal iliac artery and its major branches in relation to surrounding pelvic nerves and visceral structures.

Branches of the internal iliac artery:

a. Posterior trunk
   1. Superior gluteal artery
   2. Iliolumbar artery
   3. Lateral sacral artery

b. Anterior trunk
   1. Inferior gluteal artery
   2. Internal pudendal artery
   3. Middle rectal artery
   4. Inferior vesical artery/vaginal artery
   5. Obturator artery
   6. Uterine artery
   7. Superior vesical artery
   8. Umbilical artery

Posterior trunk and superior gluteal artery

The superior gluteal artery is primarily a continuation of the posterior trunk of the internal iliac artery. The iliolumbar and lateral sacral branches may arise directly from the superior gluteal artery or as early branches within the proximal 2 cm of the internal iliac artery (5). It courses in a posterolateral direction between the S1 nerve and the lumbosacral trunk (L4-L5), toward the upper part of the greater sciatic foramen, above the piriformis muscle. The superior gluteal artery forms an anastomosis with the deep circumflex iliac artery, which connects the external and internal iliac arterial systems.

Surgical relevance

Since the branches of the internal iliac artery supply the pelvic viscera and parietal structures, ligation of the internal iliac artery during pelvic hemorrhage can reduce bleeding and arterial pulse pressure. The posterior trunk of the internal iliac artery originates within 4-5 cm of the internal iliac artery from the iliac bifurcation. The deep circumflex iliac artery anastomoses with the superior gluteal artery, which connects the external and internal iliac arterial systems. The internal iliac artery and its branches have numerous anastomoses; therefore, the risk of tissue necrosis from ligation is low, whether the ligation is proximal or distal to the superior gluteal artery. However, if the patient has disseminated intravascular coagulation, a vascular occlusive disorder, or poor anastomoses due to previous surgery, radiotherapy, or atherosclerosis, those anastomoses may not function effectively. In cases of internal iliac artery ligation, this should be performed bilaterally. The proximal (close to the superior gluteal artery or the iliac bifurcation) and distal (close to the uterine artery/close to the target organ) parts of the internal iliac artery should be ligated separately to block the vascular continuation arising from the anastomotic connections.

Anterior trunk

Inferior gluteal artery

The inferior gluteal artery lies anterior to the sacral plexus and piriformis muscle, between the S1 and S2 nerves at the posterior part of the internal pudendal artery. It exits the pelvis from the inferior edge of the greater sciatic foramen. In that region, the sciatic nerve, pudendal nerve, and internal pudendal artery accompany the inferior gluteal artery. The artery leaves the pelvis from the posterolateral edge of the sacrospinous ligament (6). At this point, the internal pudendal artery is

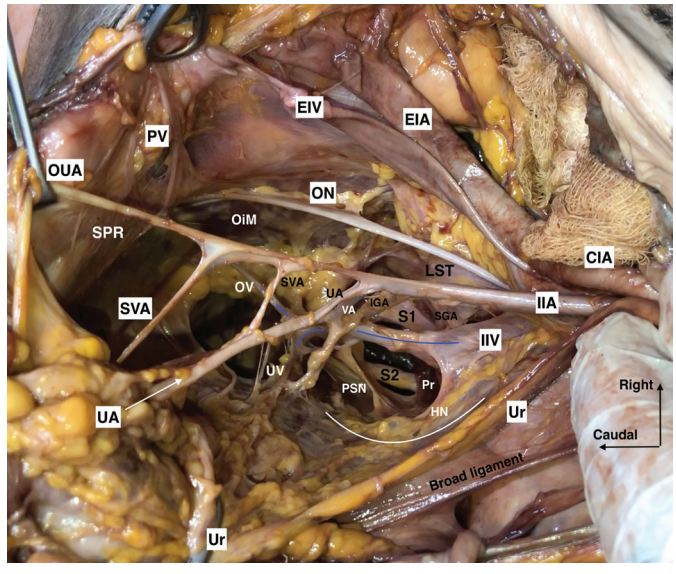

Figure 12. Internal iliac artery and its branches
CIA: Common iliac artery, EIA: External iliac artery, EIV: External iliac vein, ON: Obturator nerve, LST: Lumbosacral trunk, OiM: Obturator internus muscle, PV: Pubic vein, SPR: Superior pubic ramus, OUA: Obliterated umbilical artery, SVA: Superior vesical artery, UA: Uterine artery, VA: Vaginal artery, IGA: Inferior gluteal artery, SGA: Superior gluteal artery, IIA: Internal iliac artery, Ur: Ureter, IIV: Internal iliac vein, UV: Uterine vein, OV: Obturator vein, Pr: Piriformis, S: Sacral, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves

positioned on the anteromedial side of the inferior gluteal artery (the internal pudendal artery has a variable presence and extension), and the sciatic nerve is on the anterolateral side of the inferior gluteal artery (7). The topographic anatomy of the inferior gluteal artery and its relationship with the sacral plexus and surrounding structures is shown in cadaveric dissection in Figure 13.

Surgical relevance

The inferior gluteal artery lies posterolateral to the sacrospinous ligament. Therefore, to avoid vascular injury, the sacrospinous ligament fixation procedure should be performed 1.5 cm medial to the ischial spine.

Internal pudendal artery

The internal pudendal artery may branch off from the same vessel trunk as the inferior gluteal artery and lies anterior to the inferior gluteal artery at the anterior aspect of the sacral nerve roots and piriformis muscle. It exits the pelvis from the lower edge of the greater sciatic foramen, posterior to the sacrospinous ligament. Then, it rotates around the ischial spine, passes through the lesser sciatic foramen, and enters the perineum via the pudendal canal, which is formed by the obturator fascia inferior to the levator ani muscle. The internal pudendal artery supplies the rectum, perineum, and external genitalia through the inferior rectal artery, perineal arteries, and dorsal-deep arteries of the clitoris. The middle rectal artery and vaginal artery may branch from the internal pudendal artery. These structures exhibit anatomical variability.

Obturator artery

The obturator artery is a branch of the anterior trunk of the internal iliac artery that lies anterolaterally toward the obturator canal, located at the superolateral edge of the obturator foramen. During its course, the obturator artery is found in the obturator fossa and mostly inferior to the level of the obturator nerve (Figure 5). The anastomotic vessel connection between the obturator artery and the inferior epigastric artery is called “Corona Mortis”, which lies over the lateral part of the superior pubic ramus (8) (Figure 11). Sometimes, this anastomotic vessel may open directly into the external iliac artery. Moreover, this anastomosis is mainly found between the venous counterparts of these arteries. The anastomotic pubic vessels, so-called corona mortis vessels, enter the obturator canal from the region of the medial part of the obturator nerve.

Surgical relevance

Sacrifice of the obturator vessels during pelvic lymphadenectomy is generally well tolerated and does not result in adverse outcomes.

Uterine artery

The uterine artery branches from the anteromedial edge of the anterior trunk of the internal iliac artery as the first anteromedial branch (Figure 12). It courses within the broad ligament at the superior part of the lateral parametrium (superior to the ureter), which is termed the parauterine tissue. The tissues of the parauterine (superior to the ureter, containing the uterine artery and adjacent lymphatic tissue) and the paracervix (inferior to the ureter, containing the deep uterine vein, distal part of the pelvic splanchnic nerves as well as the inferior hypogastric plexus with the adjacent lymphatic tissue) constitutes the

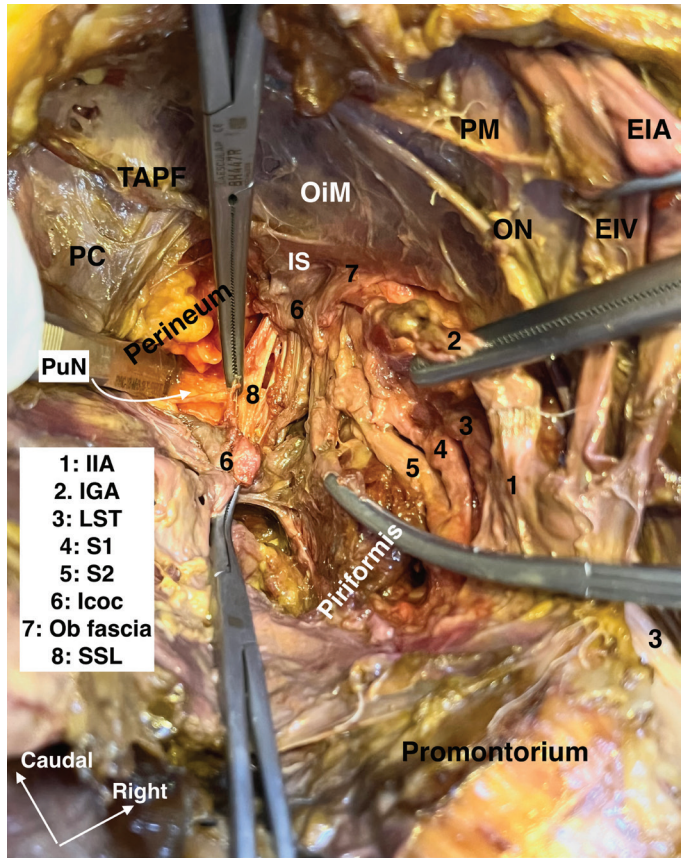

Figure 13. Inferior gluteal artery, sacral nerve roots, and pelvic floor muscles in relation to the greater sciatic foramen

EIA: External iliac artery, EIV: External iliac vein, PM: Psoas major muscle, IIA: Internal iliac artery, ON: Obturator nerve, LST: Lumbosacral trunk, OiM: Obturator internus muscle, TAPF: Tendinous arch of pelvic fascia, PC: Pubococcygeus, Icoc: Iliococcygeus, Ob: Obturator, IS: Ischial spine, SSL: Sacrospinous ligament, S: Sacral, IGA: Inferior gluteal artery, PuN: Pudendal nerve

lateral parametrium, which was historically called the "cardinal ligament"; it is a cellulo-lymphatic tissue and has no suspensory function. It extends to the level of the ischial spine. The uterine artery crosses superior (superior in the surgical supine position, anterior in the anatomical position) to the ureter approximately 1.5 cm lateral to the isthmic part of the uterus. The vaginal artery may arise separately from the anterior trunk of the internal iliac artery. It can be found as a second arterial structure inferior (inferior in surgical supine position, posterior in anatomical position) to the uterine artery and ureter, within the paracervix tissue. Alternatively, sometimes the uterine and vaginal arteries may diverge from the same trunk; the uterine artery crosses superior to the ureter, while the vaginal artery crosses inferior to the ureter and runs toward the upper vagina. The relationship between the uterine artery and ureter (the ureter lies between the uterine artery and the deep uterine vein), as well as adjacent neurovascular structures within the paracervix, is clearly demonstrated in the laparoscopic view in Figure 14.

Surgical relevance

The uterine artery is the main blood supply to the uterus. Ligation or temporary clipping of the uterine artery at its origin is a commonly used method. During this step, there should be at least 1 cm of distance between the uterine artery and the ureter to prevent thermal injury. Closure of the uterine artery at its origin is effective for treating uterine corpus pathologies (myoma or adenomyoma); however, for cervical and vaginal bleeding, its importance diminishes due to the anastomosis between the vaginal and internal pudendal arteries.

Middle rectal artery

The middle rectal artery originates from the anterior trunk of the internal iliac artery or occasionally branches off from the internal pudendal artery. It runs through the deep caudal part of the pararectal space close to the pelvic splanchnic nerves, but it is not always present.

Surgical relevance

The middle rectal artery serves as a landmark to identify the pelvic splanchnic nerves.

Umbilical artery and superior vesical artery

The umbilical artery is an active vessel during fetal development, but it becomes obliterated after birth. It is the anteriorly located longitudinal branch of the anterior trunk of the internal iliac artery that attaches to the perivesical fatty tissue and peritoneum, forming the medial umbilical fold at the posterior aspect of the anterior abdominal wall. This fold serves as a landmark for the paravesical space (Figure 7). The superior vesical artery branches from the proximal patent region of the umbilical artery and supplies the bladder. However, the superior vesical artery can be sacrificed without loss of function. This segment is distal to the branching point of the uterine artery.

Surgical relevance

The umbilical artery acts as a landmark for the paravesical and prevesical spaces.

Venous system

External iliac vein

The femoral vein becomes the external iliac vein as it passes beneath the inguinal ligament, which lies inferior in the surgical supine position. The external iliac vein is situated posteromedially in relation to the external iliac artery. At the caudal aspect of the external iliac artery, the deep circumflex iliac vein traverses superiorly over the artery before draining into the external iliac vein (Figure 11). The deep circumflex iliac vein is the distal caudal border for pelvic lymph node dissection. The inferior epigastric vein similarly drains into the external iliac vein. In addition, an anastomotic vessel may be present between the obturator vein and either the inferior epigastric or external iliac vein and this connection is referred to as the venous corona mortis.

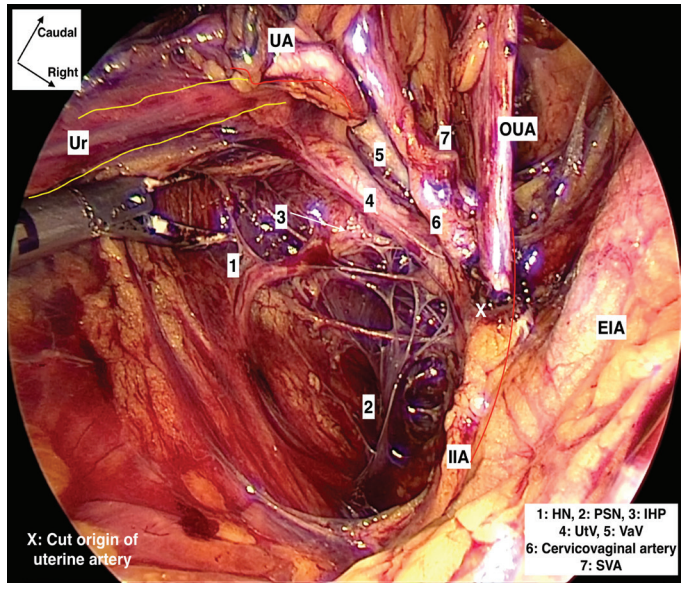

Figure 14. Uterine artery with the parauterine and paracervix tissue, related neurovascular structures
IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, UtV: Uterine vein, VaV: Vaginal vein, SVA: Superior vesical artery, EIA: External iliac artery, OUA: Obliterated umbilical artery, IIA: Internal iliac artery, Ur: Ureter, UA: Uterine artery

Internal iliac vein

The internal iliac vein lies inferior (inferior in surgical supine position and posterior in anatomical position) to the internal iliac artery and slightly at the lateral edge (9). It receives visceral drainage from the vesical, uterine, and rectal plexuses, and parietal drainage from the obturator and gluteal regions (Figure 12). The internal iliac vein is positioned anterior to the sacral plexus, and its tributaries serve as important landmarks for identifying the nerves of the sacral plexus. Pelvic splanchnic nerves are located inferior to the deep uterine/vaginal vein or lie at the same level as the deep uterine vein, a large visceral vein that drains the vesical and vaginal plexuses. The lumbosacral trunk is positioned lateral to the gluteal veins or internal iliac vein, and the cranial aspect of the obturator nerve is located lateral to the main trunk of the internal iliac vein.

Surgical relevance

Injury to the internal iliac vein and its tributaries may result in substantial hemorrhage. These vessels can be ligated in the event of bleeding. The internal iliac vein is positioned inferiorly to the internal iliac artery; therefore, meticulous care must be exercised during internal iliac artery ligation to prevent accidental venous injury.

Several venous plexuses or veins that drain into the internal iliac vein require notable considerations during pelvic surgery, as their extensive anastomoses can lead to hemorrhage. These include the vesical and vaginal veins in the paravaginal area, the sacral veins located at the medial edge of the internal iliac vein anterolateral to the sacrum, and the gluteal veins at the lateral edge of the internal iliac vein.

Common iliac veins

The external iliac vein and internal iliac vein unite anterior to the sacroiliac joint at the cranial part of the obturator fossa, caudal to the iliac bifurcation. The right common iliac vein is located posterolateral to the right common iliac artery, while the left common iliac vein is positioned posteromedial to the left common iliac artery. The left common iliac vein lies in the upper part of the presacral space over the L5 vertebra between the right and left common iliac arteries (Figure 2).

Surgical relevance

The left common iliac vein represents an at-risk anatomical structure for injury during laparoscopic optic trocar insertion via the umbilicus, as well as in the course of paraaortic lymphadenectomy.

Inferior vena cava

The right and left common iliac veins converge approximately 1-1.5 cm caudal to the aortic bifurcation on the right aspect of the abdominal aorta, thereby forming the inferior vena cava (Figure 2). Numerous tributaries are present on the anterior surface of the inferior vena cava, communicating with lymphatic structures. The most prominent of these is associated with the common iliac nodes and referred to as the "Fellow's vein" (10). The L veins drain into the inferior vena cava, with those originating from the left traversing posterior to the abdominal aorta. The right ovarian vein enters the inferior vena cava cranial to the level of the inferior mesenteric artery, while the left ovarian vein drains into the left renal vein. Renal veins enter the inferior vena cava at a point approximately 3-4 cm cranial to the level of the inferior mesenteric artery. Upon mobilization of the horizontal segment of the duodenum, the left renal vein is visualized anterior to the abdominal aorta.

Surgical relevance

Tears in the tributaries of the inferior vena cava, including the "Fellow's vein", may result in bleeding from the vena cava. During paraaortic lymphadenectomy, it is important to be aware of venous renovascular variations, such as retroaortic or circumaortic left renal veins (Figure 15). Therefore, the interaortocaval and supramesenteric lateral aortic zone must be dissected very cautiously.

Retroperitoneal nerves

Both somatic and autonomic nerves from the L and sacral plexus are situated in the retroperitoneal area.

Lumbar plexus

The L plexus is located at the lateral side of the L vertebrae and posteromedial to the psoas major muscle (Figure 16). Nerves from the anterior rami of L1 and L4 spinal roots are part of the L plexus. The 12th thoracic nerve contributes to the L1 nerve. The L5 nerve contributes to L4, forming the lumbosacral trunk (L4-L5).

Nerves of the L plexus

1. Iliohypogastric nerve.
2. Ilioinguinal nerve.
3. Genitofemoral nerve.
4. Lateral femoral cutaneous nerve.
5. Femoral nerve.
6. Obturator nerve.

Iliohypogastric and ilioinguinal nerve

The iliohypogastric nerve originates at the L1 level, with input from T12, while the ilioinguinal nerve arises from L1. Both nerves course along the craniolateral side of the psoas major muscle, pass over the quadratus lumborum posterior to the kidney, and pierce the transversus abdominis muscle to lie between the transversus abdominis and internal oblique muscles as they curve around the iliac crest (Figure 16). The ilioinguinal nerve is positioned caudal and medial to the iliohypogastric nerve. It traverses the inguinal canal without entering through the deep inguinal ring and exits via the superficial inguinal ring. The ilioinguinal nerve accompanies the round ligament within the inguinal canal.

The iliohypogastric nerve provides sensory innervation to the skin above the pubis, mons pubis, and the superolateral gluteal region. It also innervates part of the transversus abdominis and internal oblique muscles. The ilioinguinal nerve supplies sensory innervation to the skin of the superomedial thigh, groin, and labium majus.

Surgical relevance

Lower transverse abdominal incisions, including Pfannenstiel or lateral laparoscopic trocar placement, carry a risk of

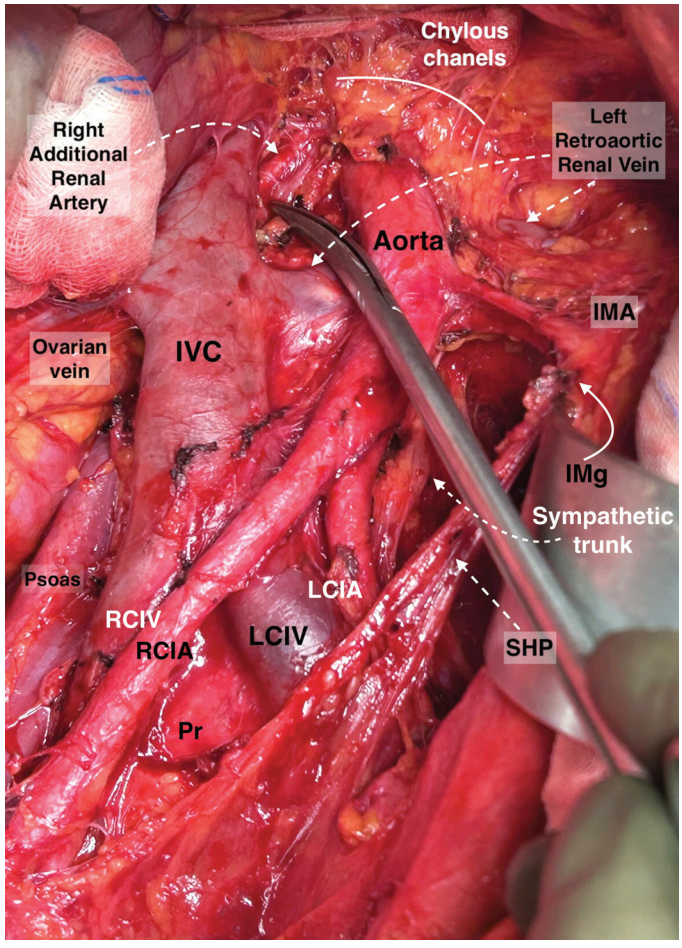

Figure 15. Retroaortic left renal vein and right additional renal artery emposing the danger zones at the supramesenteric lateral aortic space and inter-aortocaval region

IVC: Inferior vena cava, RCIA: Right common iliac artery, RCIV: Right common iliac vein, LCIA: Left common iliac artery, LCIV: Left common iliac vein, Pr: Promontorium, IMA: Inferior mesenteric artery, SHP: Superior hypogastric plexus, IMg: Inferior mesenteric ganglion

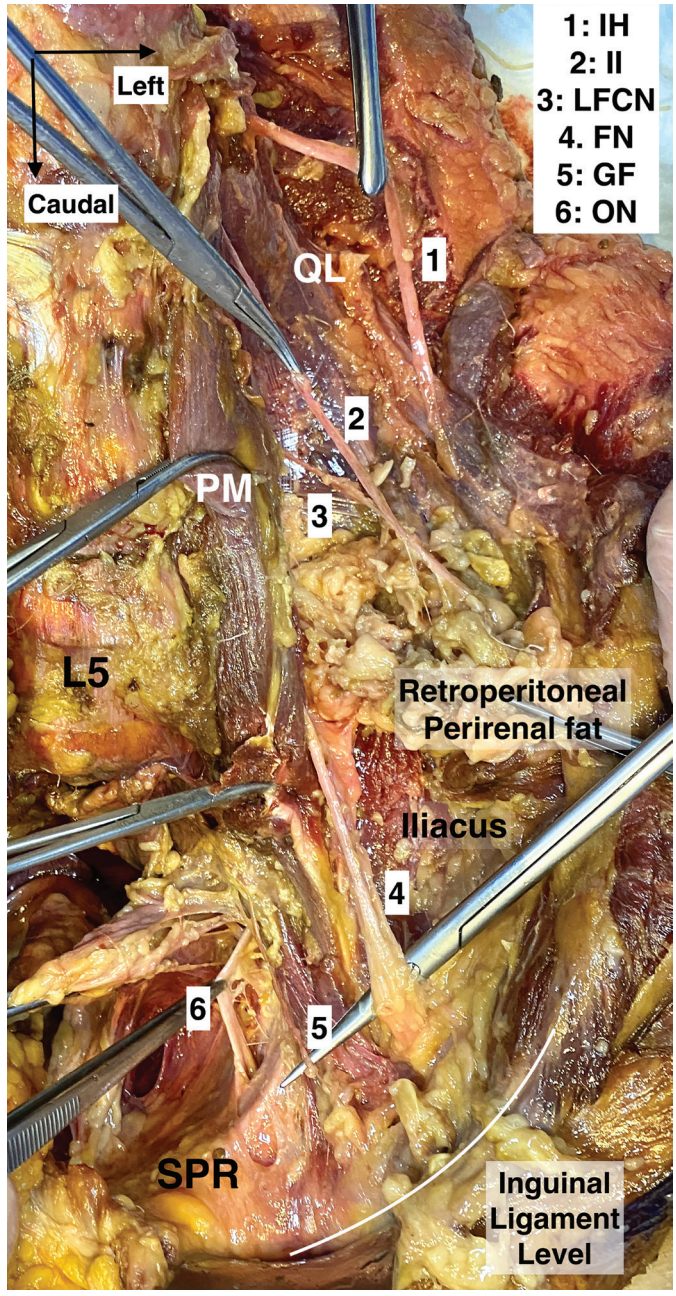

Figure 16. The lumbar plexus nerves

PM: Psoas major muscle, QL: Quadratus lumborum muscle, IH: Iliohypogastric nerve, II: Ilioinguinal nerve, LFCN: Lateral femoral cutaneous nerve, FN: Femoral nerve, GF: Genitofemoral nerve, ON: Obturator nerve, SPR: Superior pubic ramus, L: Lumbar

iliohypogastric nerve injury, potentially resulting in suprapubic burning pain or sensory loss.

Genitofemoral nerve

The genitofemoral nerve arises from the L1 and L2 spinal nerves (7). It pierces the craniomedial portion of the anterior surface of the psoas major muscle and proceeds along the anterior surface of the psoas fascia, lateral to the external iliac artery (Figure 17). Near the level of the iliac bifurcation, it divides into the genital and femoral branches. The genital branch passes through the inguinal canal by entering the deep inguinal ring and travels with the round ligament within the canal. The femoral branch follows the path of the external iliac artery and the femoral nerve. The genitofemoral nerve supplies sensory innervation to the external genitalia via the genital branch and to the skin of the femoral triangle (upper anterior thigh) via the femoral branch. In females, the genitofemoral nerve functions solely as a sensory nerve.

Surgical relevance

The genitofemoral nerve is at risk of injury during pelvic lymphadenectomy, particularly when dissecting laterally to the external iliac artery, and during lateral aortic or lateral caval lymph node dissection (Figure 17). Injury may result in paresthesia in the labial region.

Femoral nerve

The anterior rami of the L spinal nerves form the L plexus. The posterior division of L2-4 forms the femoral nerve, while the anterior division of L2-4 forms the obturator nerve. The femoral nerve is located at the deep posterolateral aspect of the psoas major muscle, positioned between the psoas major and iliacus muscles (11, 12). Due to its posterolateral location to the psoas major muscle, direct identification requires dissection of the iliopsoas fascia and medial mobilization or dissection of the psoas major (Figure 18). The femoral nerve passes posterior to the inguinal ligament (posterior in anatomical position, inferior in surgical supine position) and enters the femoral triangle laterally, lateral to the femoral artery. It provides motor innervation to the anterior thigh muscles, including the iliacus, sartorius, pectineus, and quadriceps femoris, and supplies sensory innervation to the anterior and medial thigh, as well as the medial leg and foot.

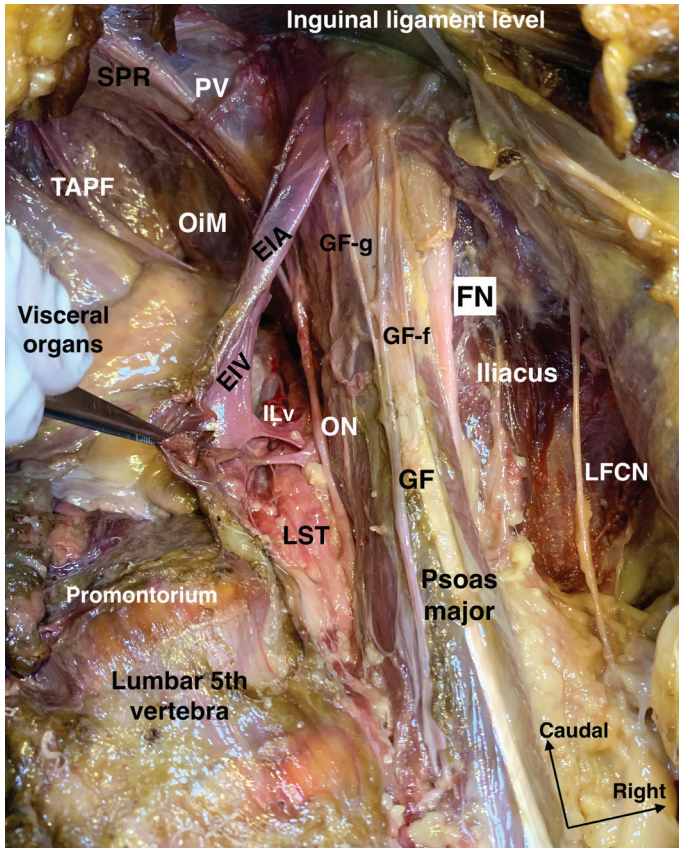

Figure 17. Lumbar plexus nerves at the lateral aspect of the pelvic brim and pelvis
GF: Genitofemoral nerve, LFCN: Lateral femoral cutaneous nerve, ON: Obturator nerve, LST: Lumbosacral trunk, FN: Femoral nerve, GF-g: Genitofemoral nerve genital branch, GF-f: Genitofemoral nerve femoral branch, EIA: External iliac artery, EIV: External iliac vein, SPR: Superior pubic ramus, PV: Pubic vein, OiM: Obturator internus muscle, TAPF: Tendinous arch of pelvic fascia, ILv: Iliolumbar vein

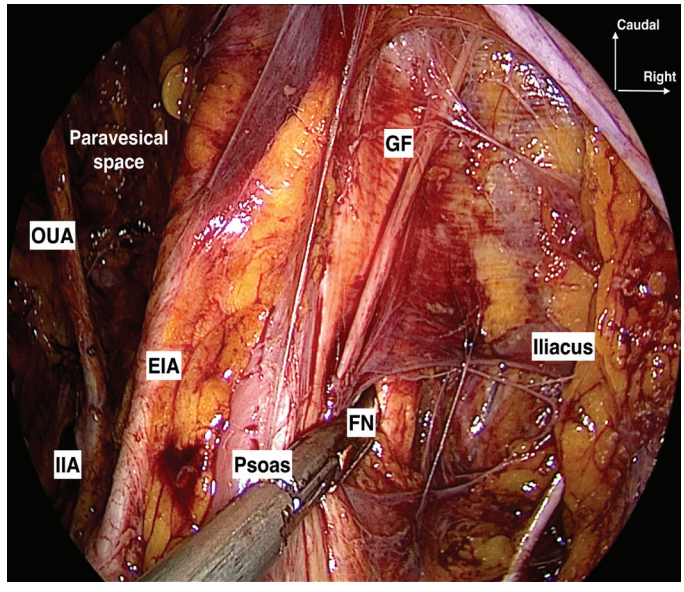

Figure 18. Femoral nerve
GF: Genitofemoral nerve, FN: Femoral nerve, EIA: External iliac artery, IIA: Internal iliac artery, OUA: Obliterated umbilical artery

Surgical relevance

During laterally extended procedures or partial resection of the psoas major muscle due to a tumoral mass, the surgeon should be cautious of the femoral nerve.

Obturator nerve

The obturator nerve is derived from the anterior divisions of the anterior rami of the L2-L4 spinal nerves. It traverses the deep, medial portion of the psoas major muscle caudal to the pelvic brim and lateral to the internal iliac vein. The nerve proceeds through the obturator fossa, situated inferior to the external iliac vein and medial to the obturator internus muscle (12). It exits the pelvis via the obturator canal at the superolateral border of the obturator foramen (Figures 5 and 17). The pubic anastomotic vessel (corona mortis), which forms a connection between the obturator and inferior epigastric vessels, passes medially to the obturator nerve to enter the obturator canal. Typically, the obturator artery and vein lie inferior to the obturator nerve (Figures 5 and 11). The obturator nerve enables adduction of the thigh through the adductor magnus, adductor brevis, gracilis, pectineus, adductor longus, and obturator externus muscles. It provides sensory innervation to the medial thigh area.

Surgical relevance

During pelvic lymphadenectomy at the obturator fossa, inferior to the external iliac vein, the obturator nerve should be identified before excision of the lymph nodes. The pectineus muscle has an adduction function and is mainly innervated by the femoral nerve (the obturator nerve also contributes branches). Therefore, if the obturator nerve is injured, the pectineus muscle may compensate for the adduction of the thigh.

Sacral plexus

The sacral plexus is formed by the anterior rami of S1-S4 (partially S4) spinal nerves, with the contribution of the lumbosacral trunk from L4-L5. The sacral spinal nerves pass through the anterior sacral foramina and run caudolaterally. The sacral plexus is located on the anterior surface of the piriformis muscle, at the posterolateral aspect of the pelvis (13). It maintains close anatomical relations with the internal iliac vessels and can be approached via dissection posterior to the internal iliac artery and vein (inferior in the surgical supine position) (Figure 19). The superior gluteal artery emerges between the lumbosacral trunk and the S1 nerve root; the inferior gluteal artery passes between the S1 and S2 roots; and the internal pudendal artery courses between the sciatic and pudendal nerves.

Branches of the sacral plexus

1. Sciatic nerve.
2. Pudendal nerve.
3. Superior gluteal nerve.
4. Inferior gluteal nerve.
5. Nerve to the obturator internus.
6. Nerve to the quadratus femoris.
7. Nerve to the piriformis.

Lumbosacral trunk

The anterior rami of L4 and L5 form the lumbosacral trunk. It runs toward the inferior edge of the greater sciatic foramen after passing lateral to the promontory and anterior to the sacroiliac joint. It unites with the S1-S3 spinal nerves to form the sciatic nerve. The lumbosacral trunk extends from the

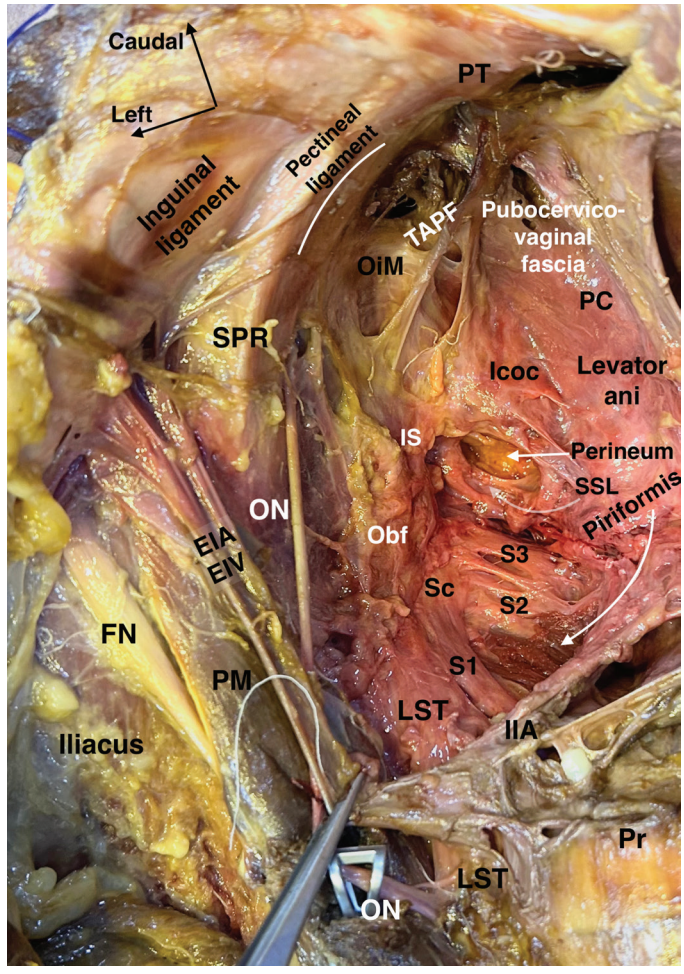

Figure 19. Sacral plexus nerves within the pelvic floor
FN: Femoral nerve, ON: Obturator nerve, LST: Lumbosacral trunk, EIA: External iliac artery, EIV: External iliac vein, PM: Psoas major muscle, S: Sacral, IIA: Internal iliac artery, Sc: Sciatic nerve, IS: Ischial spine, OiM: Obturator internus muscle, TAPF: Tendinous arch of pelvic fascia, PC: Pubocoocygeus, Icoc: Iliococcygeus, SSL: Sacrospinous ligament, Pr: Promontorium, PT: Pubic tubercle, Obf: Obturator fascia, SPR: Superior pubic ramus

craniomedial part of the obturator nerve to its caudolateral edge. The lumbosacral trunk can be dissected lateral to the internal iliac vein or common iliac vein at the medial psoas space/laterovascular plane (Figures 9, 17 and 20).

Sciatic nerve

The L4 and L5 nerve branches unite to form the lumbosacral trunk, which merges with S1-S3 to create the sciatic nerve posterior to the ischial spine (Figures 17, 19 and 20). The sciatic nerve exits the pelvis via the greater sciatic foramen (infrapiriform part), travels through the gluteal region, and splits into the common fibular and tibial nerves (14). These branches supply motor function to the hamstrings, leg, and foot muscles, including the posterior head of the adductor magnus (tibial component). Sensory innervation includes the lateral leg and dorsum of the foot (common fibular), sole and posterior leg (tibial), and posterior thigh.

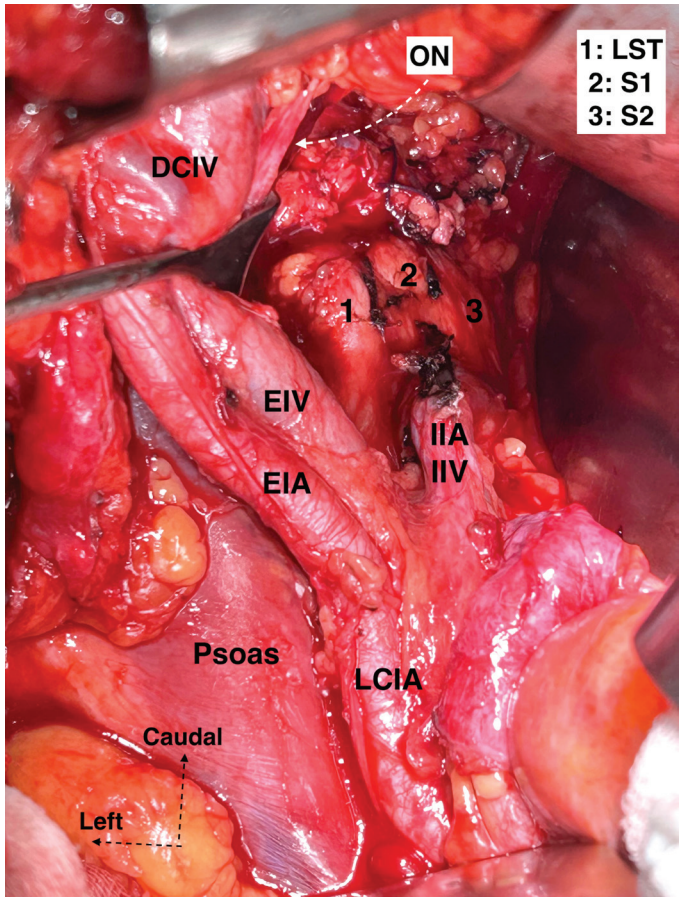

Figure 20. Components of the Sciatic nerve, the lumbosacral trunk, Sacral 1 and 2 nerves, after resection of the internal iliac vessel system and obturator fascia as Type D1 radical hysterectomy

LST: Lumbosacral trunk, S: Sacral, EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, IIV: Internal iliac vein, LCIA: Left common iliac artery, DCIV: Deep circumflex iliac vein, ON: Obturator nerve

Surgical relevance

The laterovascular plane (lumbosacral region) is important during paracervical lymphadenectomy and, at times, during resection of endometriotic nodules. The iliolumbar vessels may lie between the obturator nerve and the lumbosacral trunk. As they typically drain into the internal iliac vein, meticulous dissection in this region is essential to prevent a vascular injury. Approach to the sciatic nerve roots from the medial side of the pelvis can be performed after resection or dissection of the internal iliac vessel system. During the medial approach, the key step is to develop the paravesical space and inter-iliac area (Figure 21). Injury to the lumbosacral trunk or the sciatic nerve results in drop foot.

Pudendal nerve

The pudendal nerve originates from S2-S4. It exits the pelvis with the internal pudendal artery through the caudal (lower) part of the greater sciatic foramen, anterior to the piriformis muscle. The pudendal nerve loops around the ischial spine at the lateral part of the sacrospinous ligament and enters the perineum via the lesser sciatic foramen (Figures 13 and 19). It then lies within the duplication of the obturator internus fascia, known as the pudendal canal or "Alcock's canal", located at the lateral part of the ischioanal fossa (15). Branches of the pudendal nerve are the inferior rectal nerve, the perineal nerve, and the dorsal nerve of the clitoris. The pudendal nerve provides voluntary control of urination

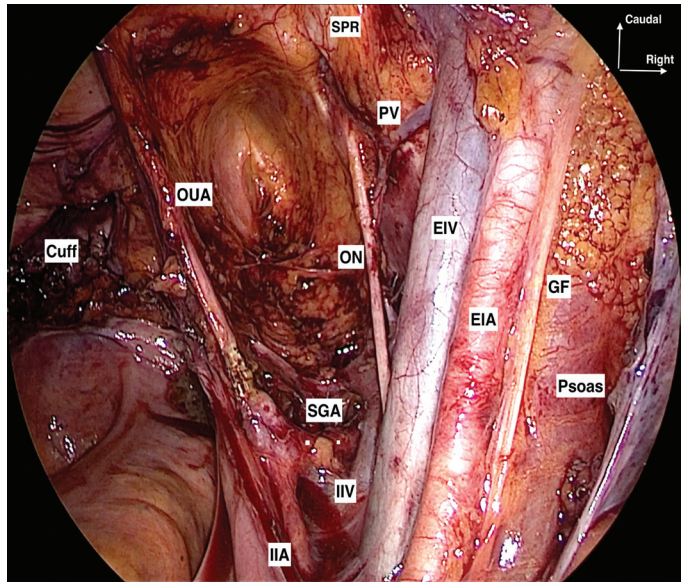

Figure 21. Medial approach, paravesical space and inter-iliac area

GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, ON: Obturator nerve, PV: Pubic vein, SPR: Superior pubic ramus, SGA: Superior gluteal artery, IIV: Internal iliac vein, IIA: Internal iliac artery, OUA: Obliterated umbilical artery

and defecation by the external urethral and anal sphincters, respectively.

Surgical relevance

Pudendal neuralgia causes chronic neuropathic pain in the external genitalia, anus, and perineum. If the diagnosis results from an entrapment, surgery may be considered.

Understanding the autonomic nerves

The peripheral nervous system is divided into two parts: the somatic part, which innervates the skin and skeletal muscles, and the visceral part (autonomic), which innervates organs and other visceral structures, such as smooth muscle and glands. Each part has motor and sensory functions. The autonomic nervous system regulates the body's involuntary responses to internal and external stimuli. While the sympathetic nervous system responds to stress, the parasympathetic nervous system supports homeostasis.

The nerves associated with the autonomic nervous system include cranial nerves (CN) III, VII, IX, and X, which are involved in parasympathetic activity, as well as nerves from the spinal cord levels T1-L2/L3 for sympathetic activity and S2-S4 for parasympathetic activity. Essentially, the presynaptic motor neuron forms synapses with the postsynaptic motor neurons in the ganglion.

Sympathetic system

Presynaptic neurons of the sympathetic system originate from the intermediolateral cell columns in the lateral horns of the T1-L2/L3 spinal cords. They leave the spinal cord through the anterior roots, run within the anterior rami of the spinal nerves toward the paravertebral ganglion (sympathetic trunk) via the white ramus communicans.

There are two types of ganglia: paravertebral and prevertebral. Paravertebral ganglia are located on either side of the vertebral column from the skull base to the coccyx, forming the sympathetic trunk (Figure 15). Each sympathetic trunk converges anterior to the coccyx, forming the ganglion impar. Prevertebral ganglia are situated anterior to the abdominal aorta around the major branches, including the celiac, superior mesenteric, aorticorenal, and inferior mesenteric ganglia.

A presynaptic neuron may synapse within the paravertebral ganglion of the sympathetic trunk at the same level where it originates from the anterior ramus of the spinal nerve. Alternatively, it can ascend and synapse at a higher paravertebral ganglion or descend and synapse at a lower one. The sympathetic trunk, for instance, distributes sympathetic nerve signals. The postsynaptic neurons leave the ganglion through the gray ramus communicans and enter the anterior ramus of the related spinal nerve to innervate sweat glands, blood vessel muscles, and arrector pili muscles.

Presynaptic neurons may traverse the sympathetic trunk (paravertebral ganglion) without synapsing, form the splanchnic nerves, and then synapse at the prevertebral ganglion. Presynaptic nerve fibers from the T5-L2/3 spinal cord levels synapse at the prevertebral celiac, superior mesenteric, aorticorenal, or inferior mesenteric ganglions. Postsynaptic splanchnic nerves are subsequently distributed by the periarterial plexuses, which include the celiac, superior mesenteric, renal, ovarian, inferior mesenteric, and superior hypogastric plexuses. These plexuses form a spider web-like structure anterior to the abdominal aorta and are collectively called the abdominal aortic plexus. They innervate the structures within the abdominopelvic viscera. The human body has five splanchnic nerves: greater, lesser, least, L, and sacral.

Parasympathetic system

The parasympathetic system is innervated by the CN III, VII, IX, X, and by the nerves of spinal cord levels S2-S4. The vagus nerve (CN X) has visceral functions that innervate the thoracic viscera and the upper abdominal organs up to the level of the splenic flexure by contributing to the celiac and superior mesenteric prevertebral plexuses. The pelvic splanchnic nerves originate from the anterior rami of the spinal nerves S2-S4. The parasympathetic motor neurons synapse at the ganglia near the target visceral organs. The postsynaptic parasympathetic nerves are located within the viscera of the target organs. The S2-S4 pelvic splanchnic nerves innervate the lower abdominal organs from the level of the splenic flexure toward the pelvic viscera.

Abdominopelvic autonomic nerves

Sympathetic nerves from the T1-5 spinal cord levels ascend to innervate the thoracic viscera. The thoracolumbar sympathetic nerves from T5-L2/3, along with parasympathetic nerves from the vagus nerve and S2-4, maintain autonomic control of the abdominopelvic organs (16-18). Specifically, T11-L2/3 and S2-4 provide the sympathetic and parasympathetic innervation to the pelvic viscera.

Presynaptic sympathetic nerve fibers from the T5-T9 ganglia form the greater splanchnic nerves, which project to the prevertebral celiac ganglion. Fibers from the T10-T11 ganglia form the lesser splanchnic nerves, terminating in the aorticorenal ganglion. Nerves deriving from the T12 ganglion create the least splanchnic nerves, extending to the aorticorenal ganglion and renal plexus. These thoracic sympathetic nerves travel posterior to the median arcuate ligament of the diaphragm to enter the abdominal cavity. There are four L splanchnic nerves

and associated ganglia. The L1 splanchnic nerve supplies the celiac, renal, and inferior mesenteric plexuses, while the L2 splanchnic nerve contributes to the intermesenteric and inferior mesenteric plexuses.

The caudal extension of these interconnected plexuses (the thoracolumbar splanchnics) forms the superior hypogastric plexus, with contributions from the L3 and L4 splanchnic nerves. The L3 splanchnic nerve contributes to the inferior mesenteric ganglion and the superior hypogastric plexus. The L4 splanchnic nerve contributes to the lower part of the superior hypogastric plexus. The intermesenteric plexus is part of the autonomic abdominal aortic plexus and connects the celiac, superior mesenteric, aorticorenal, and ovarian plexuses to the inferior mesenteric and superior hypogastric plexus (Figures 2 and 15). The superior hypogastric plexus, the inferior mesenteric plexus, and the ganglion are closely related.

The superior hypogastric plexus is located just caudal to the inferior mesenteric artery or anterior to the aortic bifurcation, anterior to the left common iliac vein, and approximately at the level of the 5th L vertebra, between the common iliac arteries and bilateral ureters, at the cranial part of the presacral space, posterior to the rectosigmoid mesentery (Figures 3 and 22). The superior hypogastric plexus primarily carries post-synaptic sympathetic and pre-synaptic parasympathetic nerves. Its sources include mainly sympathetic and parasympathetic nerves from the abdominal aortic plexus, sympathetic nerves from the L ganglia, parasympathetic nerves from the pelvic splanchnic nerves, and visceral sensory fibers.

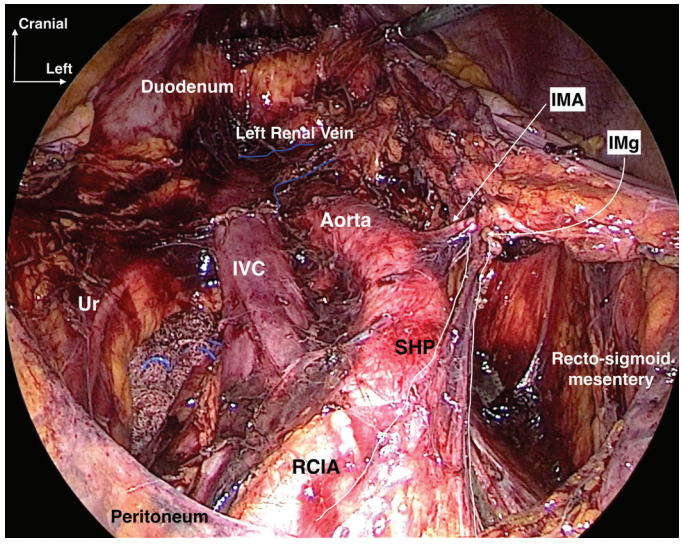

Figure 22. Superior hypogastric plexus and the connective nerve bundles with the inferior mesenteric ganglion, surgical orientation during paraaortic lymphadenectomy
IVC: Inferior vena cava, RCIA: Right common iliac artery, SHP: Superior hypogastric plexus, IMA: Inferior mesenteric artery, IMg: Inferior mesenteric ganglion, Ur: Ureter

The superior hypogastric plexus divides into the right and left hypogastric nerves, which lie caudolaterally on the anterolateral surface of the presacral space or sacrum, posterolateral to the mesorectum. Subsequently, the hypogastric nerve runs within the same fascia sheet as the ureter, approximately 2 cm inferior to the ureter (inferior in surgical supine position and posterior in anatomical position), lateral to the uterosacral ligament, and inferomedial to the internal iliac artery, at the medial part of the pararectal space. The hypogastric nerve transmits sympathetic signals from the superior hypogastric plexus to the inferior hypogastric plexus, as well as parasympathetic signals from the inferior hypogastric plexus back to the superior hypogastric plexus.

The pelvic splanchnic nerves carry presynaptic parasympathetic fibers that originate from the S2-S4 spinal cord levels. After passing through the anterior sacral foramina, they diverge from the somatic nerves and run obliquely medial toward the caudomedial part of the pelvis (Figures 6, 14). They lie at the inferomedial part of the internal iliac vein and its tributaries. This pathway extends from the posterolateral (posterolateral in the surgical supine position and craniolateral in the anatomical position) part of the pararectal space toward the anteromedial (anteromedial in the surgical supine position and caudomedial in the anatomical position) part.

Pelvic splanchnic nerves run at the inferior level of the deep uterine vein (a visceral tributary of the internal iliac vein that drains the vesical and vaginal plexuses) between the pararectal and paravesical spaces, at the deep (inferior) part of the paracervix tissue. They merge with the hypogastric nerve to form the inferior hypogastric plexus (Figure 14). This plexus is located posterolateral to the upper vaginal fornix at the anteromedial part of the pararectal space, lateral to the proximal (uterine) part of the uterosacral ligament and rectum. The rectouterine (superior part) and rectovaginal (inferior part) ligaments, as posterior parametrium, form the uterosacral ligament. This is the primary and only suspensory ligament of the uterus and upper vagina, which extends to the level of the sacral 3 and 4 vertebrae (Figure 23). The sacral splanchnic nerves, presynaptic fibers, originate from the first two sacral ganglia, pass through the sympathetic trunk, and synapse at the inferior hypogastric plexus.

The inferior hypogastric plexus is the pelvic ganglion where the sympathetic and parasympathetic nerve fibers synapse, and postsynaptic fibers extend within the secondary plexuses to reach their target organs (Figures 23-29). The secondary plexuses of the inferior hypogastric plexus include the (inferior) rectal plexus, located at the inferolateral part of the rectum lateral to the uterosacral ligament; the uterovaginal plexus, situated at the lateral part of the upper vaginal fornix and the paracolpium; and the vesical plexus, located at the inferolateral

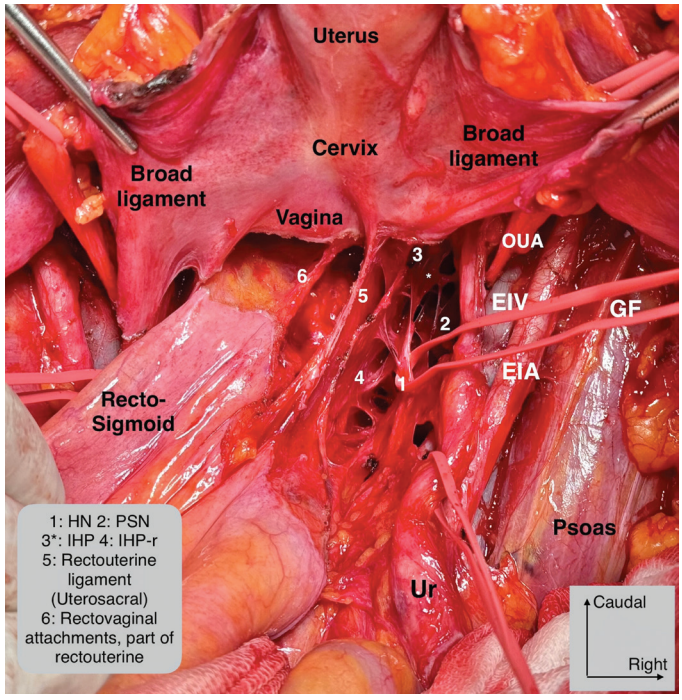

Figure 23. The hypogastric nerve, pelvic splanchnic nerves, and the inferior hypogastric plexus, anatomical relation with the uterosacral ligament (dorsal parametrium)
Ur: Ureter, GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, OUA: Obliterated umbilical artery, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, r: rectal branches

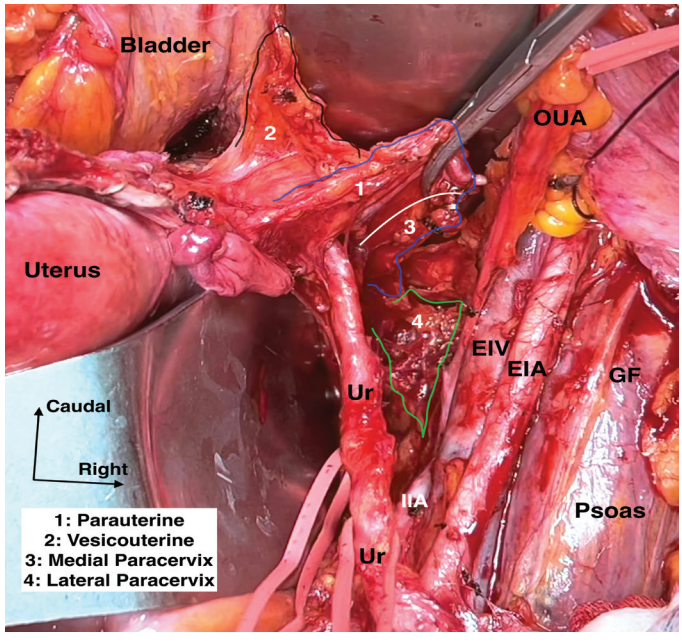

Figure 24. Continuity of the parauterine tissue with the medial paracervix and vesicouterine tissue. Dissection is performed from the superolateral aspect of the ureter, where the ureter courses through the ureteric tunnel
EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, OUA: Obliterated umbilical artery, Ur: Ureter, GF: Genitofemoral nerve

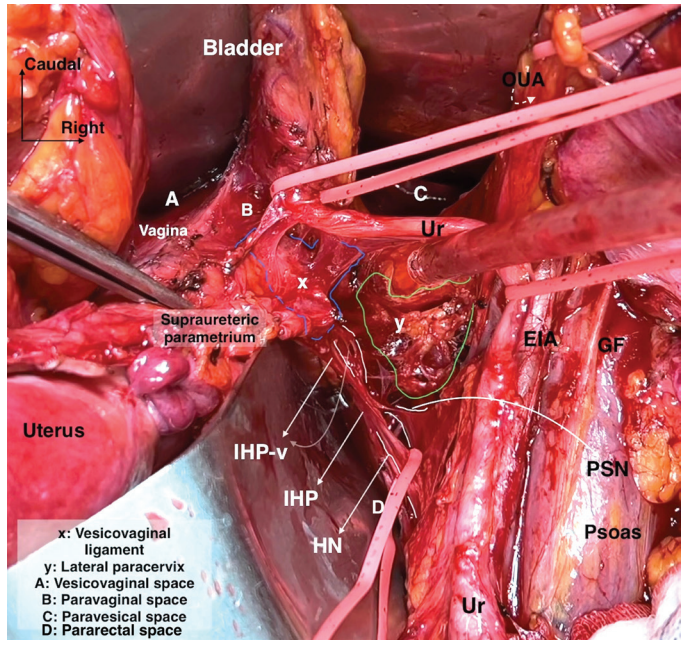

Figure 25. Vesical nerve branches arising from the inferior hypogastric plexus. Following dissection of the supraureteric parametria (parauterine tissue, medial paracervix, and vesicouterine tissue) and lateralization of the ureter from the upper vagina, the paravaginal space is developed, exposing the vesicovaginal ligament. The vesical nerve branches are identified inferior to the vesicovaginal ligament, between the vesicovaginal ligament and the lateral paracervix, along the longitudinal course of the hypogastric nerve and inferior hypogastric plexus
GF: Genitofemoral nerve, EIA: External iliac artery, Ur: Ureter, OUA: Obliterated umbilical artery, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, v: vesical branches

and anterolateral parts of the paracolpium and just inferior to the distal ureter (ureterovesical junction). The vesical branches of the inferior hypogastric plexus can be noticed inferior to the vesicovaginal ligament and at the medial aspect of the vesicovaginal venous vessels (19,20). Additionally, ganglia are present within these secondary plexuses. The inferior hypogastric plexus plays a crucial role in regulating urinary and fecal continence and sexual function.

The presynaptic parasympathetic nerve fibers, which do not synapse at the inferior hypogastric plexus, run cranially through the hypogastric nerve and pass through the superior hypogastric plexus toward the inferior mesenteric ganglion and target organs, the colon segments distal to the splenic flexure, where they may synapse.

The parasympathetic activity provides contraction of the detrusor muscle and inhibits the internal urethral sphincter to facilitate voiding. Visceral sensory fibers from the bladder base and endopelvic fascia are carried by the parasympathetic

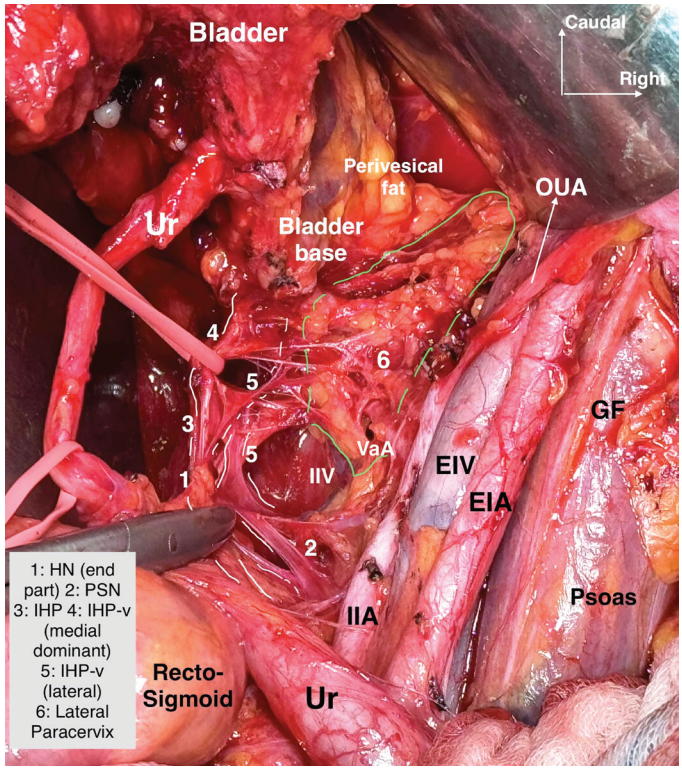

Figure 26. Lateral paracervix and pelvic autonomic nerves as a surgical step during selective systematic nerve-sparing Type C2 radical hysterectomy

GF: Genitofemoral nerve, EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, OUA: Obliterated umbilical artery, Ur: Ureter, IIV: Internal iliac vein, VaA: Vaginal artery, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, v: vesical branches

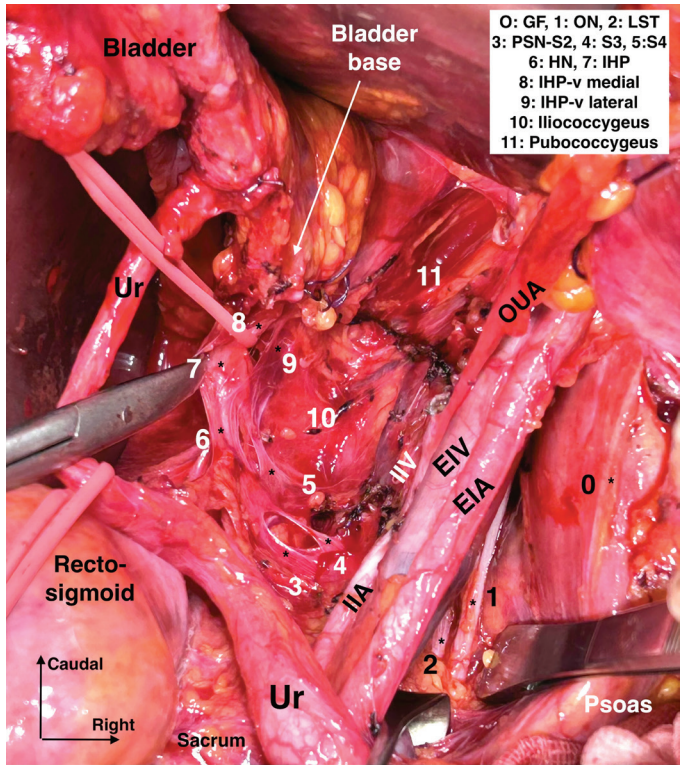

Figure 27. Pelvic autonomic and somatic nerves, exposure after selective systematic nerve-sparing Type C2 radical hysterectomy, open surgery

EIA: External iliac artery, EIV: External iliac vein, IIA: Internal iliac artery, IIV: Internal iliac vein, OUA: Obliterated umbilical artery, Ur: Ureter, GF: Genitofemoral nerve, ON: Obturator nerve, LST: Lumbosacral trunk, S: Sacral, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, v: vesical branches

afferents, while the sympathetic afferents transmit those from the superior part of the bladder. Typically, reflex efferent fibers follow the course of the parasympathetic nerves. Somatic efferent fibers, which are involved in the voluntary control of the external urethral sphincter, are innervated by the pudendal nerve originating from the S2-S4 spinal cord levels.

Surgical relevance

The superior hypogastric plexus is important during low paraaortic lymphadenectomy or during the excision of the medial common iliac lymph nodes. The hypogastric nerve and the inferior hypogastric plexus with the rectal branches can be injured during dorsal (posterior) parametrium excision or endometriosis surgery. Since the inferior hypogastric plexus is located at the medial paracervix area, it can be injured during lateral parametrectomy. The pelvic splanchnic nerves can be injured during lateral paracervix resection, lateral parametrectomy, and during the excision of the paracervical lymph nodes. The vesical branches of the inferior hypogastric plexus can be injured during ventral (anterior) parametrium, vesicovaginal ligament, and lateral paracervix resection. The pararectal space is the key area for identifying the pelvic autonomic nerves in nerve-sparing procedures (Figure 30). On the other hand, the most important issue is to preserve the target rectal and vesical branches arising from the inferior hypogastric plexus. Following the dissection of the supraureteric parametria (parauterine tissue, medial paracervix, and vesicouterine tissue) and lateralization of the ureter from the upper vagina, the paravaginal space (Yabuki's space-fourth space-Okabayashi's space) is developed between the upper vagina and distal ureter, exposing the inferiorly lying vesicovaginal ligament (Figures 25 and 29). The vesical nerve branches are identified inferior to the vesicovaginal ligament, between the vesicovaginal ligament and the lateral paracervix although it should be noted that some nerve fibers pass through the vesicovaginal ligament, along the longitudinal course of the hypogastric nerve and inferior hypogastric plexus.

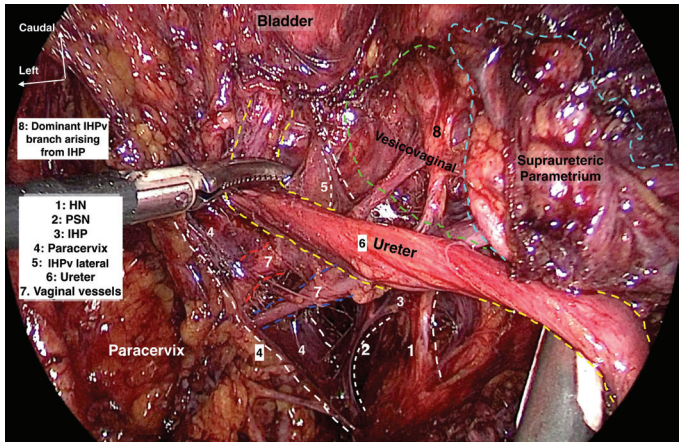

Figure 28. Pelvic autonomic nerves at the paracolpium level, laparoscopic surgery
IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, v: vesical branches

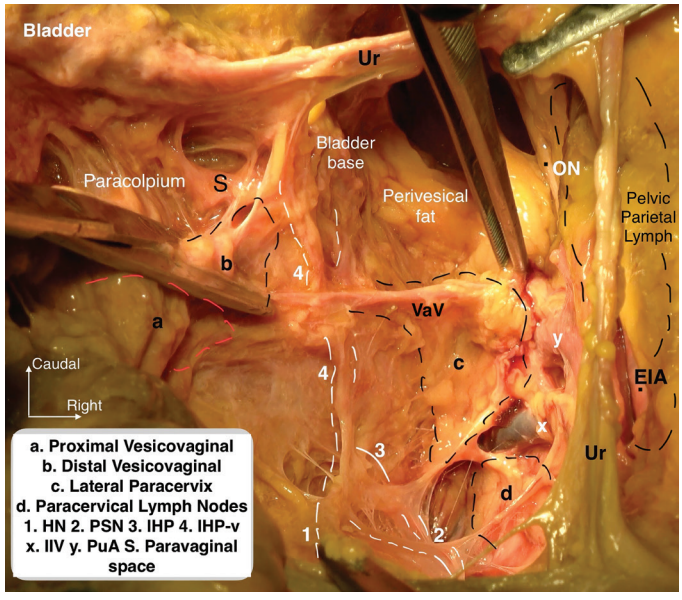

Figure 29. Pelvic autonomic nerves and the parametrium, cadaveric dissection (limited dissection bias)
EIA: External iliac artery, Ur: Ureter, ON: Obturator nerve, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, PSN: Pelvic splanchnic nerves, v: vesical branches, IIV: Internal iliac vein, PuA: Pudendal artery, VaV: Vaginal vein/Deep uterine vein

Conclusion

Precise knowledge of pelvic neurovascular anatomy and its spatial organization in pelvic avascular spaces is indispensable when performing complex pelvic surgery. This pictorial essay illustrates surgically relevant anatomical planes and key landmarks that guide retroperitoneal dissection and neurovascular preservation. Integrating this anatomical understanding into surgical practice facilitates a safer dissection,

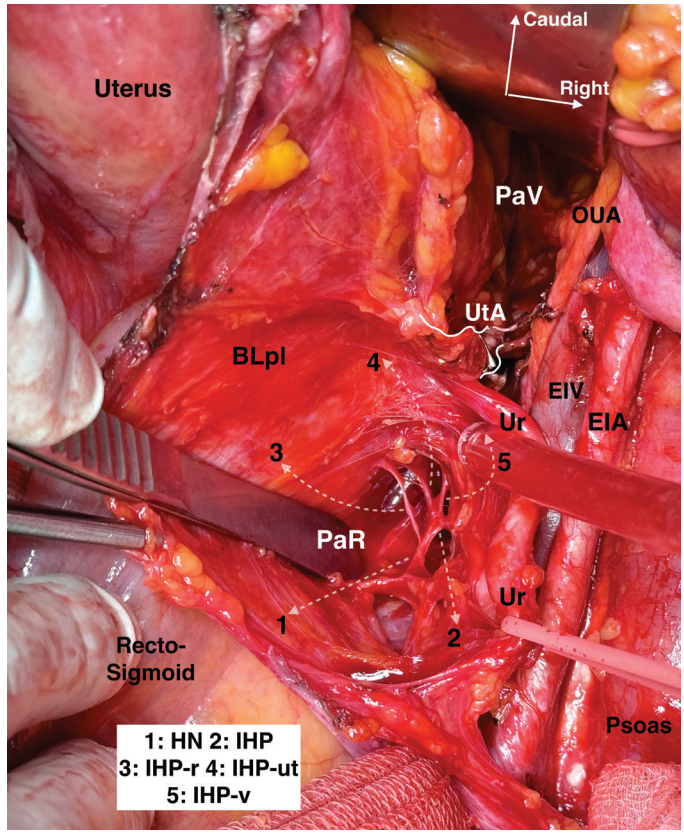

Figure 30. The pararectal space is the key area to identify the pelvic autonomic nerves during the nerve-sparing procedures
EIA: External iliac artery, EIV: External iliac vein, OUA: Obliterated umbilical artery, Ur: Ureter, UtA: Uterine artery, BLpl: Broad ligament posterior leaf, PaV: Paravesical space, PaR: Pararectal space, IHP: Inferior hypogastric plexus, HN: Hypogastric nerve, r: rectal, ut: uterine, v: vesical

reduces the risk of complications, and supports functional outcomes in advanced gynecological and gynecological oncology procedures.

Footnotes

Author Contributions: *Surgical and Medical Practices: İ.S., K.G.S., S.K., M.O., İ.T., E.H., H.R.Y., Concept: İ.S., K.G.S., Design: : İ.S., K.G.S., S.K., M.O., Data Collection or Processing: İ.S., K.G.S., S.K., M.O., İ.T., E.H., H.R.Y., Analysis or Interpretation: İ.S., K.G.S., İ.T., E.H., H.R.Y., Literature Search: İ.S., K.G.S., S.K., M.O., Writing: İ.S., K.G.S.*

Conflict of Interest: *No conflict of interest is declared by the authors.*

Financial Disclosure: *The authors declared that this study received no financial support.*

Peer-Review: *Koray Görkem Saçıntı is a member of the Editorial Board of the Journal of the Turkish-German Gynecological Association. However, he was not involved in the editorial decision of the manuscript at any stage.*

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