Contents

SECTION 1 BASICS AND ANATOMICAL ASPECTS OF ENDOSCOPIC SURGERY

Chapter 2

Clinical Anatomy for Gynecological Laparoscopic Surgery

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INTRODUCTION

Knowledge of human anatomy is a fundamental part in medical education of every physician. In particular, before disturbing the integrity of human body by surgical interventions, an awareness about anatomical structures and landmarks is of utmost importance. This prerequisite holds true especially for laparoscopic procedures in which anatomical structures are approached and addressed differently as compared to open surgery. Thus, the aim of this chapter is to highlight the topographic anatomy of female pelvis, providing a basis for both efficient and safe laparoscopic operations.

ABDOMINAL WALL AND TROCAR PLACEMENT

Abdominal wall is the first natural barrier to be penetrated to gain access to peritoneal cavity or retroperitoneal space. Typical entry sites are predetermined by the topographic architecture of muscles, fasciae and blood vessels. The anterior abdominal wall is composed of three lateral muscles (external and internal oblique muscles, transverse abdominis muscle) and one ventral muscle (rectus abdominis muscle) on both sides separated along the midline by a connective tissue band (linea alba). From inside, abdominal musculature is covered by fascia transversalis, preperitoneal fat and peritoneum itself. Below umbilicus, the peritoneal layer displays five folds: median umbilical fold (obliterated urachus), two medial umbilical folds (obliterated umbilical arteries) and two lateral umbilical folds (inferior epigastric vessels) (Fig. 2.1).[1]

The first trocar entry to create pneumoperitoneum is usually performed at the lower part of umbilicus. After the incision of cutis and subcutis, abdominal wall is lifted up and Veress needle is placed at a 45° angle to penetrate into abdominal cavity. Other systems provide an ability of direct entrance without the use of Veress needle. Nevertheless Veress needle represents state of the art for entering abdominal cavity. While crossing the abdominal wall layers, two successive losses of resistance ("jolts") are perceived, as the needle or trocar pierces muscular fascia and peritoneum. This twofold loss of resistance indicates correct access into peritoneal cavity avoiding a false inflation of pre- or extraperitoneal space.[2]

Placement of additional trocars depends on different procedures to be performed. Normally, trocars are placed in a triangle 10–15 cm lateral and inferior of umbilicus in the region of inguinal fossa. During passage of the abdominal wall, care has to be taken not to injure urinary bladder, especially when not completely emptied or closely attached to the abdominal wall by adhesions and intestine, in particular when peritoneal adhesions are present (Figs. 2.2A and B). Moreover, inferior epigastric vessels are at risk for injury, which can lead to significant bleeding.[2] Inferior epigastric vessels originate medially to the deep inguinal ring and ascend underneath the peritoneum and transversalis fascia to reach and enter rectus abdominis muscle.

FEMALE PELVIC CAVITY AND ORGANS

The female pelvic cavity is divided into three compartments: an anterior compartment with urinary bladder and urethra, a middle compartment with uterus, adnexa and vagina, and a posterior compartment with rectum and anal canal (Fig. 2.3).[1-4] The *anterior compartment* is delimited in front by pubic

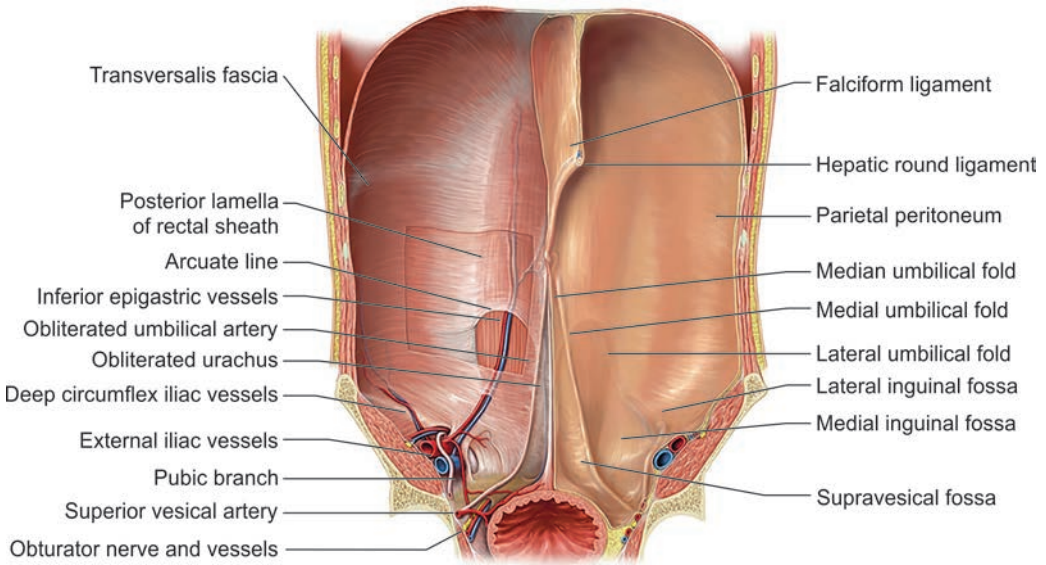
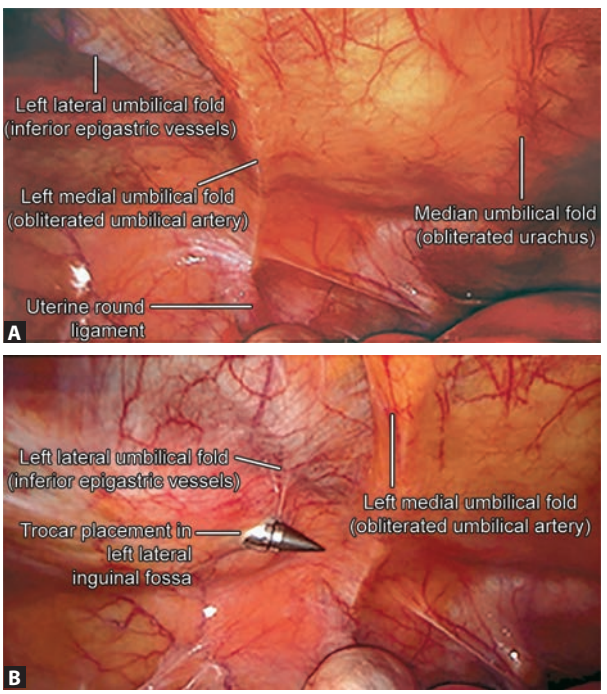


Fig. 2.1: Back side of the anterior abdominal wall.
Reproduced from Schünke et al.[13]



Figs. 2.2A and B: Laparoscopic view onto the left anterior abdominal wall. The three umbilical folds are discernible (A); the entry site of the trocar (B) is lateral to the lateral umbilical fold.

bone and prevesical space and laterally by pelvic sidewall comprising pectineal ligament (Cooper's ligament) and internal obturator muscle. Between the dorsal wall of urinary bladder and urethra and the anterior vaginal wall extends the vesicovaginal/urethrovaginal septum. The *middle compartment* extends between vesicovaginal/urethrovaginal septum and rectovaginal septum and contains uterus, uterine tubes, ovaries and vagina. Ureter crosses the middle compartment at the level of uterine cervix to reach vesical trigonum. Behind rectovaginal septum extends the *posterior compartment* containing anorectum surrounded by perirectal fascias. The dorsal compartment is delimited posteriorly by the concave surface of the sacral bone covered by presacral fascia and blood vessels.[5]

The uterovaginal complex is supported by pelvic floor and additionally fixed to pelvic wall by *uterine ligaments* (Fig. 2.4). Uterine ligaments comprise broad ligament, uterine round ligament, transverse cervical ligament, uterosacral ligament and pubocervical ligament. The *broad ligament* is a wide-stretched connection between the middle pelvic compartment and pelvic sidewall. It displays three peritoneal folds on each side converging from different origins of inner abdominal and pelvic walls toward the uterine cornu. These folds include funicular meso (anterior fold), mesosalpinx (middle fold) and mesovarium (posterior fold). The *uterine round ligament* extends from uterine fundus below and lateral to uterine cornu to deep inguinal ring and is accompanied by a branch from uterine artery and lymphatic vessels draining into superficial inguinal lymph nodes. The *transverse cervical ligament (cardinal ligament of Mackenroth)* connects uterine cervix and vaginal fornix to pelvic sidewall. Besides its mechanical function, it represents a main route of vascular, lymphatic and nervous supply to uterus. The *uterosacral ligament* attaches to uterine cervix and upper vagina and extends along rectal sidewall

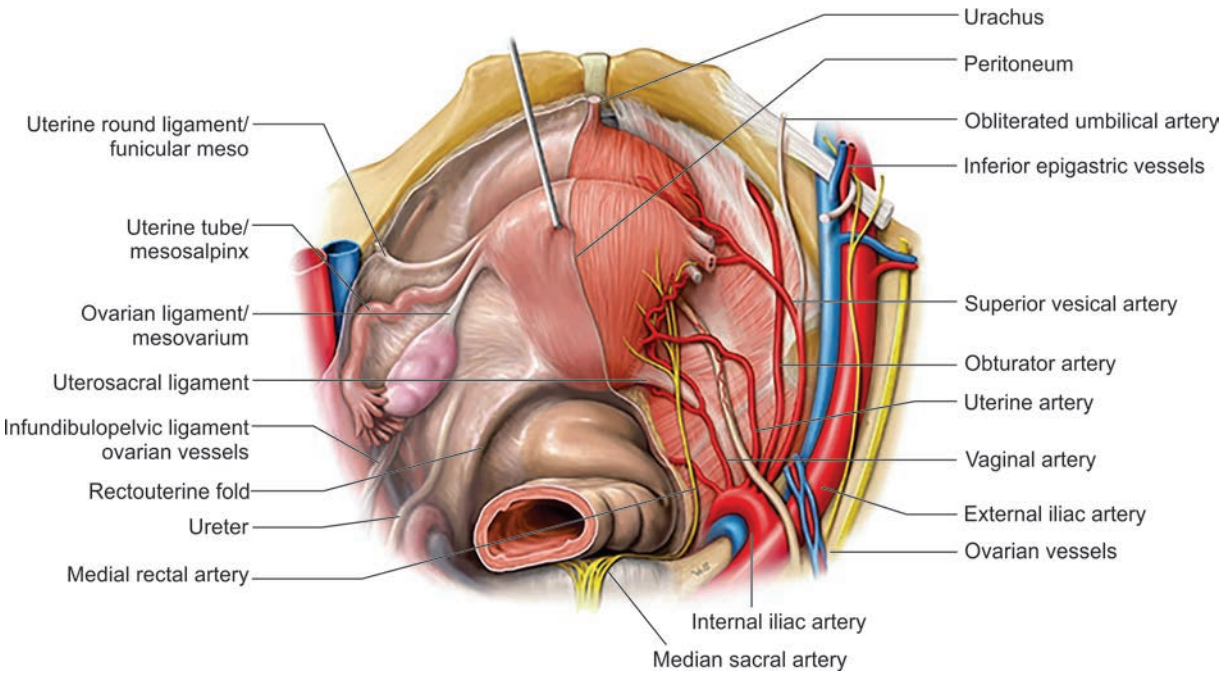


Fig. 2.3: Cranial view into the female pelvic cavity. The peritoneum, uterine adnexa and parametrial tissue are removed on the right side to expose the pelvic arteries, ureter and pelvic autonomic nerves.
Reproduced from Schünke et al.[13]

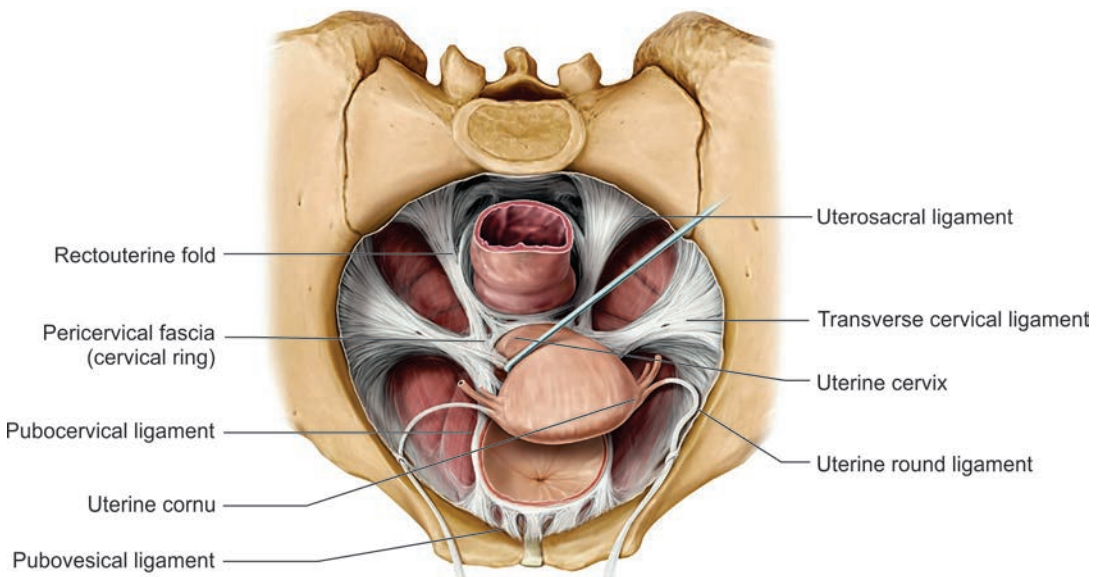


Fig. 2.4: Uterine ligaments. The rectum and urinary bladder are cut transversely, the uterus is shifted to the left side.
Reproduced from Schünke et al.[13]

toward sacrum before inserting at lower sacral vertebrae. The *pubocervical ligament* connects the pubic bone with uterine cervix running along urethra and bladder neck.[6-9]

Mesometrium is an embryologically defined tissue compartment comprising the neurovascular supply and major lymphatic drainage routes of the uterus. The clinical significance of mesometrium has received special attention after the introduction of total mesometrial resection (TMME) for uterine cancer. Mesometrium can be subdivided into vascular mesometrium containing the uterine blood vessels and surrounding lymphofatty tissue with mesometrial lymph nodes and ligamentous mesometrium corresponding to uterosacral ligaments and rectovaginal septum. Surgical approach is based on

the concept that tumor spread is initially confined to permissive ontogenetic compartments and its corresponding lymph node basins, so that complete removal of these embryologically defined tissue compartments results in an optimal tumor control with low morbidity.[10,11]

ANATOMIC TOPOGRAPHY, VASCULARIZATION AND INNERVATION OF THE URETER

As ureter crosses the middle pelvic compartment, knowledge of its topographic anatomy and relationship to other organs and structures is essential for safe and considerate laparoscopic surgery. Reasons for high vulnerability of ureter are its considerably long course (25–30 cm) along the interface between retro- and intraperitoneal space, its morphological appearance and size similar to vascular structures, as well as relatively common congenital anomalies (e.g., ureter duplex, ureter fissus, crossed ureter, retrocaval ureter).[2,12]

Abdominal segment (Fig. 2.5) originates from renal pelvis and extends to pelvic brim in front of psoas muscle. The course of ureter may vary from a paravertebral position close to either the vena cava or aorta to a lateral position along the outer border of psoas muscle. Ureter is crossed anteriorly by ovarian blood vessels and posteriorly by genitofemoral nerve. On the left side, ureter additionally undercrosses the root of sigmoid mesocolon and inferior mesenteric pedicle. On both sides, there is a close relationship between ureter and infundibulopelvic ligament. Thus, care should be taken to protect ureter underneath its peritoneal fold when mobilizing uterine adnexa.[12]

The *pelvic segment* (Figs. 2.3 and 2.5) enters pelvic cavity anterior to common iliac artery on the left side and anterior to external iliac artery on the right side. Ureter further descends underneath peritoneum and is related laterally to the branches of internal iliac artery (obturator, superior vesical and uterine artery) and obturator nerve and medially to uterosacral ligament and its corresponding rectouterine fold as well as to inferior hypogastric plexus (*see* Fig. 2.8). Before reaching urinary bladder via vesicouterine ligament, the ureter has to undercross uterine artery in anterior oblique direction at the angle of vaginal fornix (para- cervix). Because of its close relationship to uterine cervix and artery, great attention has to be paid to this area for the integrity of the ureter.[13]

Vascularization of ureter is supplied by various sources of blood vessels due to its considerable length, including branches from aorta, renal, ovarian and internal iliac arteries. Whereas arteries approach the abdominal segment of ureter from the medial side, the pelvic segment is supplied by arteries originating from the lateral side (Figs. 2.6A and B). Consequently, when mobilizing or dissecting ureter, this principle has to be taken into consideration to preserve the blood vessels. Although interruption of one of many blood supply sources can be compensated by an anastomotic system running within the adventitial layer, excessive denudation of ureter over a long distance should be avoided.[2]

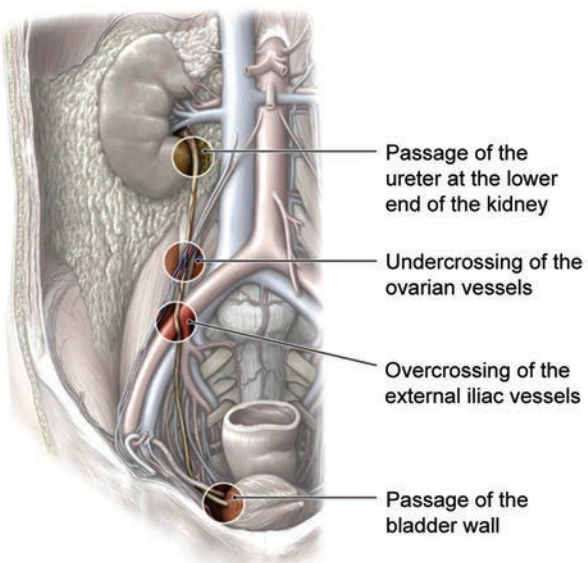
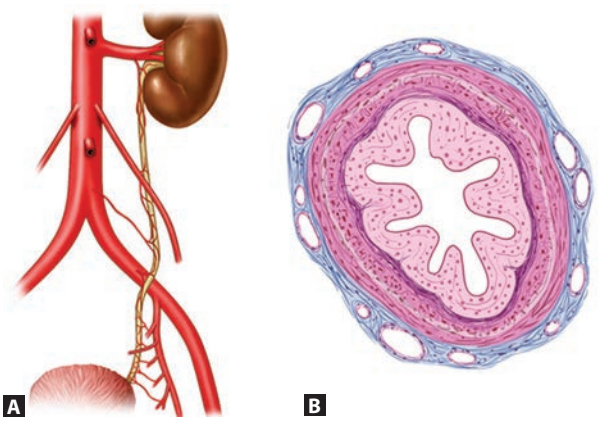


Fig. 2.5: Anatomical relationships of the ureter. Localization of common ureteric injuries.
Reproduced from Schünke et al.[13]



Figs. 2.6A and B: Vascularization of the ureter (A); cross-section of the ureter (B).

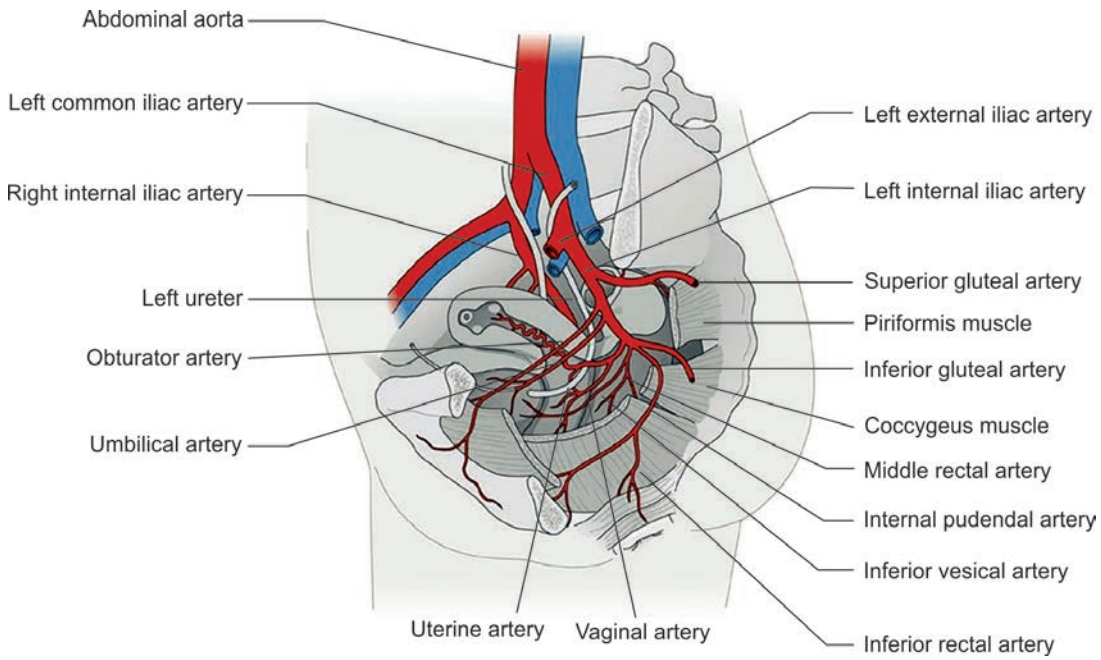


Fig. 2.7: Branches of the internal iliac artery in the female pelvis. Reproduced from Schünke et al.[13]

Nerve fibers responsible for the *autonomic innervation* of ureter derive from renal, superior and inferior hypogastric plexus mediating its peristaltic movements and pain perception. Furthermore, to prevent urinary bladder dysfunctions due to injury of vesical nerve plexus, manipulation of distal ureter at the region of vesicoureteric junction and vesical trigone should be avoided.[12]

VASCULARIZATION OF THE FEMALE PELVIS

Female pelvic organs are mainly supplied by internal iliac arteries (Fig. 2.7). The common iliac arteries originate at aortic bifurcation in front of the left side of fourth lumbar vertebra. They pass along the medial borders of psoas major muscle without giving off major branches and diverge into external and internal iliac arteries. Whereas external iliac arteries follow psoas major muscle until traversing lacuna vasorum through femoral ring to reach the lower limb, internal iliac arteries descend into pelvic cavity in a posterocaudal direction and then divide into anterior and posterior trunk. To expose internal iliac artery, the adjacent and sometimes overlying infundibulopelvic ligament and ovary have to be shifted upward. The common, external and internal iliac veins are located medially or dorsomedially to their arterial counterparts.[3]

The anterior trunk of internal iliac artery comprises the following branches: superior vesical artery, uterine artery, vaginal artery, middle rectal artery, obturator artery, internal pudendal artery and inferior gluteal artery (Fig. 2.7). Frequently, an anastomotic connection between obturator and inferior epigastric artery is provided by a pubic branch running across the pubic bone over pectineal ligament. This anastomotic branch is also termed as corona mortis ("crown of death"), because in earlier times of surgery, an inadvertent injury of this vessel led to serious bleedings during inguinal or femoral hernia repair.[3] The posterior trunk of internal iliac artery comprises iliolumbar artery, lateral sacral arteries and superior gluteal artery (Fig. 2.7).[3]

As a general rule, larger veins such as the common, external and internal iliac veins follow the course of their arterial counterparts. In most cases, veins run medially or dorsomedially to arteries. The same observation holds true for most of the parietal branches (e.g., obturator, pudendal, gluteal veins) of internal iliac artery; whereas visceral branches display different features: urinary bladder, uterus and vagina are drained by venous plexus, which are interconnected with each other and release blood into multiple vesical, vaginal and uterine veins. These veins do not strictly accompany and run parallel to the arteries until they enter internal iliac vein.[3]

It has to be emphasized that during laparoscopic surgery requiring pneumoperitoneum, pelvic veins often collapse due to intraperitoneal pressure exerted onto the thin venous walls. Thus, special care must be taken to clearly identify and respect pelvic veins, because injury may occur inadvertently and lead to troublesome bleeding sometimes only evident after diminishing the intraperitoneal pressure.[2]

AUTONOMIC INNERVATION OF THE FEMALE PELVIS

The challenge of oncologic surgery is to aim at the highest radicalness to ensure curative therapy and lowest loss of function to maintain quality of life after surgery. Therefore, it is essential to take care of the preservation of pelvic sympathetic and parasympathetic nerves. The integrity of this autonomic nervous system is essential for the maintenance of urinary continence and urinary bladder function as well as of sexual and anorectal functions.[14,15]

The preganglionic *sympathetic nerve fibers* emerge from lower lumbar and upper sacral spinal cord segments and pass along aorta on both sides as periaortal trunks. The periaortal nervous network fuses ventrolaterally to aorta to form inferior mesenteric and superior hypogastric plexus. In front of promontorium and slightly left to midline, superior hypogastric plexus divides into left and right hypogastric nerves. Hypogastric nerves often consist of various nerve bundles and are embedded within parietal pelvic fascia extending in front of the sacral concavity. Gentle traction of hypogastric nerve will lift up this fascial sheath in a tent-like fashion thereby enabling to follow its course along the pelvic sidewall down to inferior hypogastric plexus (Fig. 2.8).[16]

Parasympathetic nerves derive from sacral part of the parasympathetic nervous system residing in sacral spinal cord. Together with ventral branches of sacral spinal nerves S2–S4, these pelvic splanchnic nerves leave ventral sacral foramina and pierce parietal pelvic fascia on both sides to join the hypogastric nerves. Pelvic splanchnic nerves coming from dorsocaudally and the hypogastric nerves coming from dorsocranially converge to form inferior hypogastric plexus (Fig. 2.8).

Inferior hypogastric plexus is a mixed autonomic nerve plexus composed of both sympathetic and parasympathetic nerves and is embedded within parietal pelvic fascia covering the pelvic sidewalls. The nervous meshwork extends medially to internal iliac artery and gives off multiple branches to the pelvic organs. Posteriorly, *rectal plexus* diverges at the level of rectal ligaments and enters the rectal wall accompanied by middle rectal artery. Anteriorly, inferior hypogastric plexus releases a lateral and medial trunk. Lateral trunk corresponds to vesical plexus running toward the bladder—lateral and underneath the ureter. The nerve bundles follow branches of vesical artery and further ramify to innervate distal ure-

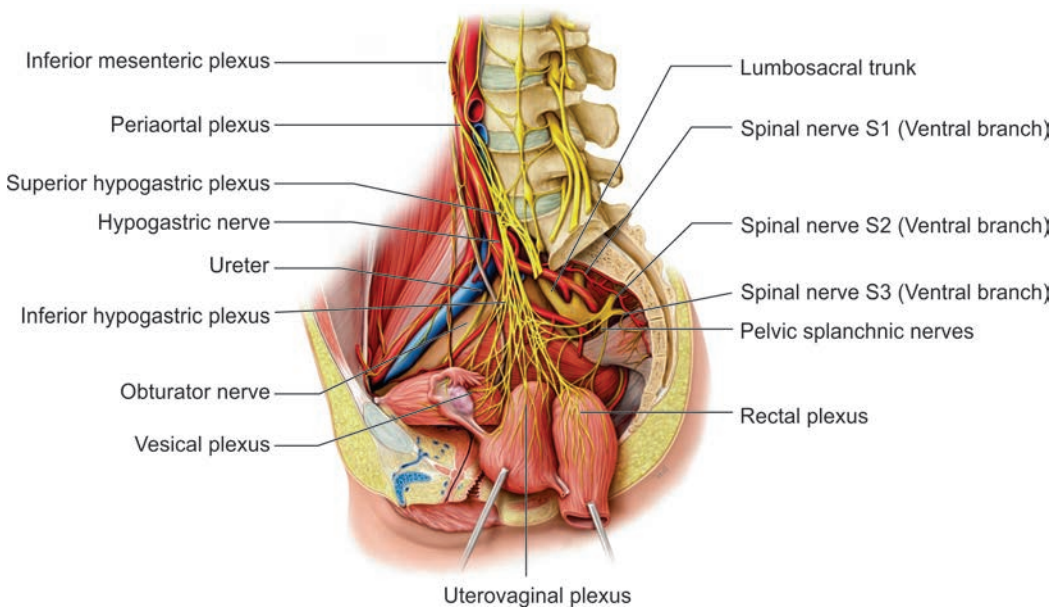


Fig. 2.8: Autonomic nerve supply of female pelvic viscera. Uterus and rectum are shifted to the left side to expose the pelvic autonomic nerve plexus.
Reproduced from Schünke et al.[13]