



Topographic And Anatomical Pathways Of Tumor Dissemination In The Female Reproductive Organs

**Jalolov Oybek
Kamoliddinovich¹**

¹Andijan State Medical Institute,
Senior lecturer at the Department of Oncology
doc.oybek79@mail.ru, ORCID: 0009-5949-0219

ABSTRACT

The anatomy of the female pelvis and reproductive organs constitutes a highly complex topographic-anatomical system that plays a pivotal role in understanding the clinical behavior and dissemination patterns of malignant tumors. Accurate knowledge of pelvic anatomy is of particular importance in gynecologic oncology, where surgical strategy, the extent of lymphadenectomy, identification of metastatic routes, and prognostic assessment are directly influenced by individual variations in vascular supply, lymphatic drainage, organ syntopy, and fascial and cellular compartments.

Although classical anatomical descriptions of the pelvic organs are well established, contemporary evidence derived from magnetic resonance imaging, computed tomography, three-dimensional reconstruction, and lymphatic mapping has revealed substantial interindividual anatomical variability. These findings necessitate a critical reappraisal of traditional concepts regarding tumor spread, especially in cervical cancer, endometrial carcinoma, and ovarian neoplasms. The present review aims to synthesize current data on the anatomy of the female pelvis, fascial planes, cellular spaces, and lymphatic pathways, as well as to elucidate their role in the dissemination of gynecologic malignancies and their implications for surgical management.

Keywords:

uterus, vagina, blood vessels, lymph nodes, endometrial carcinoma, fasciae, parametrial tissue.

Introduction.

The pelvic cavity (pelvis minor) is a space bounded by bony structures (sacrum, coccyx, ischial, iliac, and pubic bones) in which the organs of three systems are located in close proximity: the urinary, reproductive (genital), and distal digestive systems. Understanding the patterns of their arrangement and fixation is fundamental to clinical medicine, particularly obstetrics, gynecology, and abdominal surgery. [19] .

The topographic and anatomical relationships of the female pelvic structures remain underexplored in the literature, complex, and sometimes controversial. This is

due to the insufficient study of its fascial elements, anatomical structures, the significant number of variant types of organ blood supply, and the topographic relationships of vascular structures. This pertains to the subperitoneal tissue of the pelvis and its underlying ligamentous apparatus. The peak of research on these issues occurred in the second half of the last century. [2] .

The problem of malignant tumors of the pelvic organs is due to the increasing incidence of these tumors. In recent years, according to the WHO, there has been a trend toward some stabilization of cervical cancer incidence , but there has been an increase in cancers of other

locations, such as the endometrium, bladder, and rectum. [16].

Invariably, over a number of years, in every third cancer patient with pelvic tumors, the process is locally and regionally widespread at the time of diagnosis, and in 20% of cases, distant metastases are detected [20].

Surgery or radiation therapy, as independent methods, play a primary role in the treatment of pelvic tumors. Surgical interventions of one kind or another are used in 45-50% of patients with malignant pelvic tumors, but despite the use of various surgeries and the development of new radiation and chemotherapy regimens, treatment results are not entirely satisfactory. [3].

1. Anatomical and topographic characteristics of the pelvis and its organs .

1.1. Anatomical landmarks of the pelvis .

The bony framework of the female pelvis (like the male) consists of four bones: the paired coxal bones (left and right), the sacrum, and the coccyx. The pelvic bone consists of three fused bones—the ilium, ischium, and pubis.

The pelvis is divided into two sections: the upper, wider one – the large pelvis and the lower, narrower one – the small pelvis. The boundary between them is the boundary line, linea terminalis , formed by the sacral promontory, the arcuate line of the iliac bones, the pubic crests and the upper edge of the symphysis [11].

The greater pelvis is the upper, wider part of the pelvic ring, which is actually part of the abdominal cavity. The female reproductive organs are not normally located in the greater pelvis, except during pregnancy.

The pelvis is the lower, bony region containing the uterus, cervix, vagina, ovaries, and fallopian tubes. The boundaries of the pelvis determine the growth and spread of tumors. [12].

The promontory (sacral promontory) is the anterior superior protrusion of the body of the first sacral vertebra, a key point dividing the abdominal and pelvic cavities. It serves as an important landmark both in topographic anatomy and in surgical navigation, especially during lymph node dissection.

The linea terminalis (limit line) is an arched line formed by the edge of the sacral promontory, the arched line of the ilium, and the superior edge of the pubic bone. It separates the greater pelvis (pelvis major) and the lesser pelvis (pelvis minor). [13].

1.2 . General topography of the pelvic organs

The uterus is a cavity organ of the female reproductive system that ensures the development and gestation of the fetus. The uterus is located centrally, between the urinary bladder anteriorly and the rectum posteriorly. The typical position of the uterus is characterized by anteversion and anteflexion. It is primarily divided into the body of the uterus and the cervix. The fundus is the uppermost part of the body, located above the angles of the uterus, where the fallopian tubes pass into it. The cavity of the body of the uterus is flattened in the anteroposterior direction. In the frontal plane , it has a triangular shape with the apex facing downward toward the cervix. The slightly narrowed transition between the body and the cervix is the cervix . The cervix is divided into a supravaginal and vaginal portion. The cervical canal is divided into the internal os (the opening at the isthmus between the body and the cervix) and the external os (the opening into the vagina) [8].

The cervix (cervix uteri) is located in the lower part of the uterus and opens into the vagina through the external os. It lies at the junction of the body of the uterus and the vaginal fornix and is anchored by ligaments (cardinal and uterosacral ligaments), which provide relative stability. Normally, the axis of the cervix is tilted posteriorly, forming an angle with the vagina, and is directed toward the posterior surface of the pubic symphysis. [15].

The vagina is a fibromuscular tube extending from the external genitalia to the cervix. It is located between the bladder and urethra anteriorly and the rectum posteriorly. The upper portion of the vagina forms the vaginal fornices, the deepest of which is the posterior fornices. This fornication is an important anatomical area in gynecologic oncology given its proximity to the peritoneal recess (excavatio rectouterina, or space of Douglas).

The ovaries are located in the pelvic cavity lateral to the uterus, in the region of the

ovarian fossa (fossa ovarica). This fossa is bounded anteriorly by the external iliac vessels and posteriorly by the ureter and internal iliac artery. The ovaries are fixed by their own ligaments and the suspensory ligament of the ovary, allowing for not only a vertical position but also variable lateral displacement—a factor that is taken into account when assessing tumor spread. [11] .

The fallopian tubes (tubae uterinae) run within the broad ligament of the uterus along its superior margin, originating from the angles of the uterus and extending laterally toward the ovary. Within the pelvis, their position is relatively flexible, especially in the ampullary region, the primary site of development of tubal and primary peritoneal carcinomas.

1 . 3 . Syntopy of organs and clinical significance of variations

The topographic relationships of the pelvic organs determine the clinical course of tumors and the extent of surgical intervention. [11] .

The uterus is located in the center of the pelvis and has the following relationship :

- the anterior surface is in contact with the bladder ;
- the posterior surface is adjacent to the rectum. Between the uterus (and the upper part of the vagina) and the rectum is the deepest space of the peritoneal cavity - the rectouterine pouch, or Douglas's pouch (excavatio rectouterina) ;
- the broad ligaments of the uterus (ligamenta lata uteri) are located laterally , at the base of which pass the main vascular-nerve bundles, including the uterine arteries and veins. The uterine appendages (ovaries and fallopian tubes) are localized in the mesentery of the broad ligament, lateral to the body of the uterus ;

Vagina . The vagina is located between the bladder and urethra anteriorly and the rectum posteriorly. The upper third of the vagina is in close contact with the cervix, forming the vaginal fornices, which can be infiltrated by cervical carcinoma. The posterior fornices are directly adjacent to the dorsal sinus of Douglas.

The urinary bladder is adjacent to the anterior vaginal wall and the lower uterine segment. In cases of cervical tumor spread, infiltration of the vesicouterine tissue is one of the signs of local spread.

Rectum . Adjacent to the posterior surface of the vagina along the middle and lower third. Infiltration of the recto-vaginal tissue accompanies advanced cases of cervical and vaginal cancer.

1 . 4 . Fascial and cellular spaces of the pelvis

The fascial-cellular spaces of the small pelvis are formed by the layers of the pelvic fascia and a number of anatomical “compartments” that are of key importance in the spread of tumor processes and in performing surgical interventions. [17] .

Main fascial spaces:

1. Parametrium . Located lateral to the uterus, between the layers of the broad ligament. Contains the uterine artery, venous plexuses, lymphatic drainage systems, and pelvic nerves. Parametrium involvement is a FIGO staging criterion for cervical cancer. [15] .
2. Paracolpium . Fiber surrounding the vaginal walls. Plays a role in infiltration of the vaginal vaults in carcinoma of the cervix and vagina.
3. Paravesical space (spatium paravesicale) . Located lateral to the bladder. An important area for surgical bladder mobilization and lymph node dissection.
4. The pararectal space (spatium pararectale) consists of the Okara and Lacko spaces. It is used in gynecologic oncology surgery for radical hysterectomies. [17] .

Among the cellular spaces, there are several more distinct ones that are of great clinical significance. These include the prevesical space, the lateral portions of the parauterine space (parametrium), the retrorectal space, and the paired lateral spaces. Catheterization and bladder exposure are performed through the prevesical space. The uterine arteries and venous plexuses are located in the lateral portions of the parauterine space, and parametritis is quite common. The retrorectal space contains lymph nodes and venous plexuses. The lateral space on each side contains the main pelvic blood vessels and the main groups of lymph nodes. [1] .

1 . 5 . Blood supply, venous plexuses, lymphatic drainage .

The main source of arterial blood supply to the pelvis and its organs is the internal iliac artery, which is one of the terminal branches of the common iliac artery and, descending along

the lateral wall of the pelvis, divides into anterior and posterior branches, from which parietal branches extend to the walls of the pelvis and visceral branches to its organs.

Visceral branches of the internal iliac artery (a. iliaca interna):

1) inferior vesical artery. Supplies blood to the main part of the bladder;

2) uterine artery (a. uterina) . This is the largest and most important branch of the internal iliac artery. Its topography is of practical importance, especially with the pelvic ureter. Shortly after originating in the subperitoneal floor of the small pelvis, the uterine artery is located behind the descending ureter. At the base of the broad ligament of the uterus, the artery again meets the ureter, but it is located anterior to and above the ureter. The distance between them is 1-2 cm. Knowledge of the topography of the uterine artery is of great importance when performing surgical interventions on the uterus;

3) Vaginal artery (a. vaginalis) . It passes along the wall of the vagina, giving off numerous branches to it , and also forms anastomoses with the uterine and internal pudendal arteries. ;

4) middle rectal artery (a. rectalis media) . Supplies blood to the rectum;

5) The internal pudendal artery (a. pudenda interna) exits the pelvic cavity through the infrapiriform foramen into the gluteal region, and then passes through the lesser sciatic foramen into the ischiorectal fossa.

Between arteries the pelvis contains numerous and varied interarterial anastomoses [12] .

The parietal branches of the internal iliac artery, as usual, are accompanied by veins of the same name. The veins of the pelvic organs also accompany the arteries of the same name. In the pelvis, pronounced venous plexuses are developed:

- plexus venosus uterinus ;
- plexus venosus vaginalis ;
- plexus venosus ovaricus ;
- plexus venosus vesicalis and rectalis .

These plexuses are located in the parametrium and paracolpium, causing early venous spread of tumors and high risks of bleeding during surgery. [19] .

lymphatic system, like the entire lymphatic system, is of interest to clinicians primarily as a pathway for lymphogenous metastasis, characteristic of epithelial malignancies. The pelvic cavity contains several groups of lymph nodes that are regional for lymphatic drainage from the pelvic organs. Among these, the most notable are the chains of lymph nodes located along the iliac arteries: the internal, external, and common. These nodes are called the internal iliac, external iliac, and common iliac lymph nodes. They are located in the lateral pelvic space and are removed during surgery for uterine cancer (Wertheim procedure). [5] . Another group of lymph nodes is located behind the rectum, in the retrorectal tissue, on the anterior surface of the sacrum. They are called the anterior sacral nodes. This group of lymph nodes is regional primarily for the rectum.

The lymphatic system is a key factor in tumor staging.

The following main routes of spread of malignant neoplasms of the pelvic organs are distinguished:

1. The superior and inferior paracervical lymphatic tracts . The superior tract leads to the external and common iliac nodes. Lower - to the internal iliac, obturator and presacral nodes. This typical pathway follows the sequence of cervical cancer spread: paracervical → iliac → paraaortic.

2. Infundibulo-pelvic pathway . For ovarian tumors, the main direction of metastasis is along the lig. suspensorium ovarii, which contains the vascular bundle. Metastases often reach the para-aortic nodes to the level of the renal vessels - this is an important oncological feature.

3. Round ligament of the uterus → inguinal nodes . Tumors of the lower third of the vagina and tumors of the body of the uterus with involvement of the round ligament can metastasize to the inguinal lymph nodes. [23,24] .

2. Clinical significance in oncogynecology .

2.1 . Radical operations . Radical hysterectomy is a complex surgical removal of the uterus and surrounding tissues, including the cervix, parametrium, and often the ovaries and

fallopian tubes, most often due to cancer, performed through various approaches: laparotomy (open), laparoscopic (minimally invasive), or vaginal, with removal of pelvic lymph nodes and vessels. The technique depends on the approach: laparoscopic - through mini-incisions with a video camera, laparotomy - through a large incision, vaginal - through the vagina for minimal scarring. [10].

The following types of radical hysterectomy are distinguished:

- Total hysterectomy (extirpation of the uterus), removal of the body and cervix of the uterus.
- Radical hysterectomy (with appendages) , removal of the uterus, cervix, fallopian tubes and ovaries.
- Panhysterectomy , removal of the uterus, appendages and surrounding tissues.

Extended (type C2 or D according to Querleu-Morrow): Removal of the uterus, cervix, appendages, parametrium, part of the bladder or other tissues, as well as pelvic lymph nodes, which requires resection of vessels [22].

And also by the degree of radicality (using cervical cancer as an example , Querleu-Morrow classification) :

Type A: Removal of all tissue between the cervix and ureters, minimal excision of tissue ;

Type B1: Tissue removal + partial excision of ligaments ;

Type B2: Type B1 + removal of pelvic lymph nodes ;

Type C1: Removal of all pelvic contents up to the ureters ;

Type C2 (URMR): Removal of the entire pelvic contents up to the bladder, including part of the parametrium and lymph nodes, with preservation of the nerves.

Type D: Pelvic exenteration (removal of all organs) [22].

The anatomy of the parametrium (parietal tissue) is critically important in radical hysterectomy (RHE), as it contains blood vessels (arteries and veins), nerves and lymphatics that must be preserved or safely isolated for radical tumor removal, but with the risk of injury to the ureters, vessels and nerves,

which determines the scope and complexity of the surgery (e.g., different types of RHE), affecting the risk of bleeding, pelvic organ damage and postoperative complications such as bladder dysfunction, requires careful dissection to remove cancer without unnecessary damage to healthy tissues [7].

2.2 . Lymph node dissection . Lymph node dissection (or lymph node adenectomy) after radical hysterectomy is a surgical procedure to remove regional (pelvic and sometimes para-aortic) lymph nodes along with the uterus and surrounding tissue. It is **the gold standard** for surgical treatment of early-stage cervical cancer (IA2–IIA) and some cases of endometrial cancer. Lymph node adenectomy has both diagnostic (for staging the disease) and therapeutic value , as it removes nodes along with possible micrometastases . reduces the risk of disease recurrence [5].

To avoid removing all nodes and reduce the risk of complications, doctors increasingly use detection of "sentinel" nodes (the first nodes along the lymphatic flow pathway). If these nodes are clear, the remaining nodes can be preserved. Sentinel lymph node biopsy and lymphatic mapping are used in early-stage endometrial cancer cases where imaging data does not allow for a reliable assessment of the pelvic lymph nodes. This method is based on identifying the first lymph nodes to drain lymph from the tumor [21].

To do this, a special dye is injected into the cervix, after which the stained lymph nodes—the sentinel nodes—are visualized. These nodes are then removed and histologically examined. If tumor cells are absent, further lymphadenectomy is not performed. If metastases are detected, the scope of the surgical intervention may be expanded [4].

The procedure is typically performed simultaneously with a hysterectomy. If sentinel lymph nodes cannot be identified on both sides, standard lymph node dissection of the corresponding anatomical areas is performed.

In the presence of enlarged lymph nodes according to preoperative imaging data, pelvic and para-aortic lymphadenectomy is

performed in order to clarify the surgical stage of the disease [5] .

Therefore, it is subject to removal during rectal extirpation surgery for cancer. We have already mentioned the inguinal lymph nodes, which can drain lymph from the uterus via the lymphatic vessels of the round ligament of the uterus.

2.3 . The role of visualization . Diagnostic methods such as MRI are the gold standard, which determines the state of the parametrium, the degree of vaginal involvement in the malignant process, as well as the presence of infiltration of the rectum or bladder [14] .

3. Current issues and prospects

3 .1. Lack of standards for describing fascial spaces

One of the key problems in modern gynecological anatomy remains the lack of a unified terminology for the fascial and cellular structures of the pelvis. The terms paracervix, parametrium, and paracolpium are often used synonymously, although different schools of thought refer to different anatomical volumes. This leads to difficulties:

- when comparing surgical studies;
- in training young surgeons;
- in standardization of radical operations.

The ambiguity of terms significantly complicates the assessment of intraoperative risk and the extent of resection in gynecological oncology.

3.2 . Visualization limitations

Despite progress, radiodiagnostics also has a number of limitations:

- MRI remains the best method for assessing parametrium, however, micrometastases in lymph nodes and small infiltrates of tissue may not be detected.
- CT is useful for staging, but is inferior to MRI in the assessment of soft tissue structures.
- 3D ultrasound provides good visualization of the uterus and appendages, but is uninformative for the parametrium and retroperitoneal spaces.
- Lymphatic mapping (ICG) is effective for locating SLN but requires specialized equipment and standardization of technique [6] .

Thus, even modern methods may miss early metastatic spread, especially along fascial tracts.

3.3 . Personalized surgery

Prospects for the development of gynecological oncology are associated with an individualized approach to each patient.

Future trends include:

3D anatomical modeling of retroperitoneal structures and parametria for planning the scope of surgery.

Personalized lymphatic drainage maps that take into account anatomical variations of the uterine vessels and lymphatic collectors [18] . Robot-assisted surgery allows for more precise operation in narrow fascial spaces and reduces the risk of damage to the ureter and blood vessels. Development of SLN biopsy technique as an alternative to extended lymphadenectomy in patients with early stages. Such technologies promise to reduce surgical trauma and increase staging accuracy. [9] .

Conclusion

Anatomical the features of the female pelvis play a decisive role in gynecological oncology. They determine:

- routes of tumor spread - lymphatic, vascular, fascial-cellular;
 - choice of treatment tactics, including the need for radical hysterectomy of one type or another (according to Querleu–Morrow I–III);
 - the extent of lymphadenectomy and the feasibility of sentinel lymph node biopsy;
- patient prognosis, especially for tumors of the cervix, endometrium and ovaries.

Modern imaging, surgical, and lymphatic drainage mapping techniques are gradually moving medicine closer to a personalized approach. However, standardization of fascial space terminology and improved diagnostics of micrometastases remain a necessity. Understanding subtle anatomical variations is key to improving the effectiveness and safety of surgical treatment.

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