MEDICAL UNIVERSITY – PLEVEN
FACULTY OF HEALTHCARE
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SIGNIFICANCE OF SOME RETROPERITONEAL ANATOMICAL STRUCTURES OF THE PELVIS AND THEIR VARIATIONS IN GYNAECOLOGIC SURGERY

THESIS SUMMARY

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The thesis is presented on 165 pages and contains 26 figures and 41 annexes.

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The thesis was discussed and referred for public defence by an expanded council meeting of the Department of Obstetrics, MU-Pleven.

The clinical material related to the thesis research is based on data for patients diagnosed and treated at the Gynecology Clinic at St. Anna Hospital – Varna for gynaecologic oncology diseases in the period from 2014 to 2021.

The retroperitoneal anatomy was studied by 4 cadaveric dissections and 6 lower limbs with ipsilateral pelvic walls at the Department of Anatomy, Medical University „Prof. Dr. Paraskev Stoyanov" – Varna.

The public defence of the dissertation will take place on .... from....... hours ……… in ….....

The defence materials are available to the interested parties in the Library of MU-Pleven.

СЪДЪРЖАНИЕ

ABBREVIATIONS

AA	Abdominal aorta
IVC	Inferior vena cava
RA	Renal artery
RV	Renal vein
VIL	Vena iliolumbalis
VLA	Vena lumbalis ascendens
CMOR	Corona mortis
PVS	Paravesical space
PRS	Pararectal space
AOA	Aberrant obturator artery
AOV	Aberrant obturator vein
CIV	Common iliac vein
HA	Hypogastric artery
HV	Hypogastric vein
CT	Computed tomography
MRI	Magnetic Resonance Imaging
OA	Obturator artery

INTRODUCTION

The retroperitoneal space is a part of the abdominal cavity bordered ventrally by the peritoneum parietal posterior and dorsally by the fascia transversalis and the posterior abdominal wall muscles located behind it – the initial parts of the m. transversus abdominis, m. quadratus lumborum, m. psoas major et. minor. Cranially, the retroperitoneal space reaches the diaphragm at the level of the horizontal line running through the 12th thoracic vertebra, and caudally it continues to the promontorium and linea terminalis, whence it passes directly into the subperitoneal space of the pelvis. The organs in the abdominal cavity show a different relation to the peritoneum – intraperitoneal, mesoperitoneal, retroperitoneal and extraperitoneal. Organs and anatomical structures covered by the peritoneum on one side only are designated as retroperitoneal. In the retroperitoneal space of the pelvis are located part of the pelvic organs, connective tissue ligaments, adjacent vascular-free connective tissue spaces, nerves, ureters, blood vessels and lymph nodes.

Radical hysterectomy combined with pelvic lymph node dissection and Hudson surgery for advanced ovarian carcinoma in the small pelvis are surgical interventions requiring detailed knowledge of the retroperitoneal space in the small pelvis.

In recent years, with the advent of laparoscopy, the presence of retroperitoneal tumours, and the performance of nerve-sparing surgeries for endometriosis or malignancy of the female reproductive organs, there has been a growing interest in the retroperitoneal space.

The main objective associated with studying the retroperitoneal space is to master in detail the topographic anatomy of all anatomical structures within it. The number of publications on this issue has been steadily increasing in recent years, presenting as well the relationship between classical and surgical anatomy. Emphasis has been placed on accurately identifying the individual organs and structures in the pelvis and dissection of the vascular-free spaces.

On the other hand, few publications in medical literature study the association between retroperitoneal anatomical structures and their variations in operative gynaecology.

A thorough study of the anatomical structures and their variations in the retroperitoneum of the small pelvis will significantly reduce the rate of intra- and postoperative morbidity and patient mortality.

I. AIM AND TASKS

Aim

To study the retroperitoneum's main anatomical structures and their relevant variations in operative gynaecology.

Tasks

1. To present and study the previously known approaches to the retroperitoneum of the small pelvis.
2. To study and present the previously known vascular-free spaces in the small pelvis.
3. To analyse the anatomy of the lymph nodes:
   3.1. Pelvic lymph nodes;
   3.2. Para-aortic lymph nodes.
4. To examine and present the retroperitoneal anatomy of the ureter and its variations.
5. Corona mortis, aberrant and accessory obturator arteries – variations, classification.
6. To present the anatomy, variations, and classification of vena iliolumbalis and vena lumbalis ascendens in gynaecology.
7. To study and analyse the anatomy of retroperitoneal space, the anatomical variations of retroperitoneal structures, and their association with gynaecologic surgery.

II. MATERIALS AND METHODS

1. Clinical cohort

The thesis research was based on patients diagnosed and treated for gynaecologic oncology diseases in the Gynecology Clinic at St. Anna Hospital – Varna in the period from 2014 to 2021.

During this period, 635 patients were diagnosed with gynaecological malignancies (vulvar and vaginal carcinomas are not included), of which 243 were diagnosed with cervical carcinoma, 238 with uterine carcinoma and 154 with ovarian carcinoma.

Of the 243 patients diagnosed with cervical cancer, 187 patients underwent radical hysterectomy (type B2/C1/C2) with pelvic and/or paraaortic lymph node dissection.

Of the 238 patients diagnosed with endometrial carcinoma, 149 underwent total or radical hysterectomy with adnexal surgery – 68 underwent total hysterectomy with adnexa, and 81 underwent radical hysterectomy (type B2/C1/C2) with adnexa. Pelvic and/or paraaortic lymph node dissection was performed in 82 patients.

Total or abdominal hysterectomy was performed on 98 patients of the 154 diagnosed ovarian carcinomas. Almost one-third (30) of the hysterectomies were performed via the retroperitoneal approach, the Hudson procedure. Pelvic (20 patients) and/or paraaortic lymph node dissection (14 patients) were performed in 34 of the hysterectomized patients.

Retroperitoneal anatomical structures were examined in 120 patients operated on in the Gynaecology Clinic (30 patients with ovarian carcinoma, 40 patients with endometrial carcinoma and 40 patients with cervical carcinoma, 8 patients operated on for retroperitoneal myoma and 2 patients operated on for deep pelvic endometriosis). In 95% of the cases, the patients were operated on by laparotomy (in 40 of them, the approach was entirely retroperitoneal – 30 Hudson procedures, 8 with extraperitoneal lymph node dissection and 2 patients with extraperitoneal ligation of HA). The approach was laparoscopic in the remaining 5% of patients (6 patients with endometrial carcinoma).

Retroperitoneal anatomy was also studied by 4 cadaveric dissections at the Department of Anatomy, Medical University "Prof. Paraskev Stoyanov" – Varna. Additionally, the anatomy of some vascular-free areas and aberrant obturator vessels was studied on 6 female lower limbs with part of the ipsilateral pelvic wall.

A total of 1698 anatomical structures were analysed and studied.

Lateral paravesical vascularless space – 220; medial paravesical vascularless space – 180; Latzko's space – 230; Okabayashi's pararectal space – 110; the area medial to the musculus psoas major – 50; the space at the ureteral tunnelling – 164; Okabayashi's paravaginal space – 4; Yabuki's space –6; prevesical space – 10; rectovaginal space – 90; vesico-cervical/vesicovaginal space – 107; presacral space – 54; pelvic lymph nodes – 129; para-aortic lymph nodes – 27; ureters – 220; Corona mortis – 19, aberrant vessels – 9 and accessory obturator vessels – 28; variations of vena iliolumbalis and v. lumbalis ascendens – 12; anatomical variations: double IVC – 1; double ureter – 3; ureteral diverticulum – 1; accessory aortic inferior polar RA – 1; abnormalities in the shape of the iliac artery – 11; abnormalities of the HV – 2; abnormalities of the v. circumflexa iliaca profunda – 10.

2. Methods

2.1. Surgical method

2.1.1. Total hysterectomy – performed in patients with benign pathology and endometrial carcinoma.

2.1.2. Radical hysterectomy (type C2) without pelvic lymph node dissection.

The latest Querleu–Morrow classification of radical hysterectomy, also applied in Bulgaria, was used for the radicality of the hysterectomy. It was performed on patients with cervical carcinoma.

2.1.3. Radical hysterectomy – type B2

It was performed on patients with cervical carcinoma and endometrial carcinoma.

2.1.4. Radical hysterectomy – type C1

It was performed on patients with cervical carcinoma.

2.1.5. Pelvic lymph node dissection

2.1.6. Para-aortic lymph node dissection

Lymph node dissections were performed in cancer patients for staging purposes. In patients with ovarian carcinoma, paraaortic lymph node dissection was performed as a staging and therapeutic procedure before LION procedure. After it, pelvic and paraaortic lymph node dissections were performed only in patients (with advanced disease) with intraoperative evidence of metastatic lymph nodes for optimal cytoreduction. In patients with early ovarian carcinoma, pelvic and paraaortic lymph node dissection was performed for staging purposes.

2.1.7. Hudson procedure – surgical technique

It was performed in patients with advanced ovarian carcinoma.

2.1.8. Hypogastric artery ligation

It was performed on 2 patients with advanced cervical carcinoma and profuse genital bleeding.

3. Cadaveric dissections

4. Statistical methods

4.1. Descriptive statistics

5. Photographic material

III. OWN RESULTS AND DISCUSSION

III. 1. Approaches to the retroperitoneum

III.1.1. Transperitoneal access

1. Lateral posterior retroperitoneal access

1.1. Results and surgical technique

This is the most commonly used approach. It was performed on 98 patients, of which 6 underwent laparoscopic surgery.

Ligamentum rotundum is the key to accessing the retroperitoneum in this approach. The ligament was cut and ligated. Through this ligament passes the Sampson's artery erroneously described in some anatomical manuals and textbooks as a branch of a. uterina. The artery of Sampson is a branch of a. epigastrica inferior. The transection of the lig. rotundum occurs maximally lateral to the pelvic wall but medial to the external iliac vessels. The ligament is then dilated medially and dorsally in order to exert traction on the ovarian vessels. The posterior leaflet of the uterine broad leaf is transected in a ventral-dorsal direction, lateral to the ovarian and external iliac vessels and medial to the psoas muscle. It is desirable to palpate or visualise the pulsation of the external iliac artery immediately before the incision. Nervus genitofemoralis is visualised immediately after the superficial incision. The latter is dissected and dilated laterally and as far from the operative field as possible. The external iliac vessels are visualised. The vein is localised medial to the artery. Identification of the ureter and the ovarian vessels follows. The procedure ends with a dissection of Latzko's space. The lateral posterior retroperitoneal approach is presented in Figure 1.

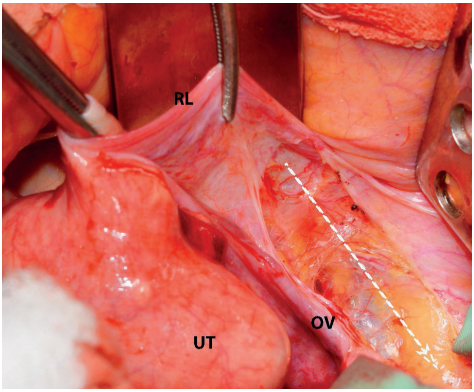

Figure 1. Lateral posterior retroperitoneal approach (right pelvic wall).
UT – uterus; OV – ovarian vessels; RL – lig. rotundum

1.2. Discussion

The described approach finds application in almost all pelvic retroperitoneal procedures. It is used to identify, mobilise, and isolate the ureter during radical hysterectomy, pelvic lymph node dissection, or for tumours located retroperitoneally and posterior to the uterus. Additionally, this approach may find application even in total hysterectomy – after visualisation of the ureter, the ovarian vessels are ligated. This avoids lesions or ligation of the ureter during transection of the ovarian pedicle.

Intraperitoneal ligation of the HA or dissection of retroperitoneal tumours in the paravesical space also requires a lateral posterior retroperitoneal approach. For tumours fully involving the paravesical space, we commence with a pararectal approach using this method. We trace the ureter and dissect it from the cardinal ligament. Thus, we attack the tumour and the paravesical space in a caudal-ventral direction.

2. Medial posterior retroperitoneal approach – *The Bermuda Triangle*

2.1. Results and surgical technique

The Bermuda Triangle in gynaecology is an anatomical description of retroperitoneal vascular access. It was performed on 20 female patients. The triangle is an area of the pelvic wall, with the walls formed by lig. Infundibulipelvicum, lig. ovarii proprium and the ureter. Incision of the posterior leaflet of plica lata was performed between the two ligaments, possibly after transperitoneal exposure of the ureter. Dissection of the loose and fatty connective tissue and visualisation of the ureter and HA follows.

2.2. Discussion

This approach finds its best application in intraligamentary myomas in the posterior leaflet of plica lata or in recurrent or metastatic lymph nodes adjacent to the pelvic wall.

3. Lateral anterior retroperitoneal approach

3.1. Results and surgical technique

It was performed on 54 patients.

Access was initiated with ligation and transection of lig. rotundum. This was followed by an incision of the anterior leaflet of plica lata in dorso-ventral direction, lateral to the lig. umbilicale and medially from the external iliac vessels. After dissection of the ligamentous connective tissue, the lateral PVS was reached, and the junction of the fascia pubocervicalis with the arcus tendinous fascia pelvis was visualised caudally (Figure 2).

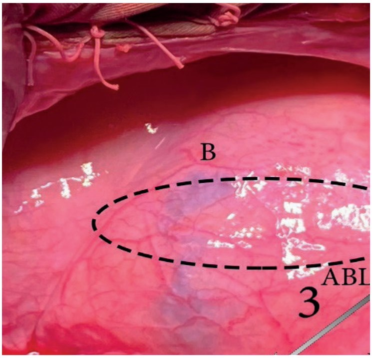

Figure 2. Lateral anterior retroperitoneal access (right pelvic wall) – arrow 1.Arrow 3 illustrates the continuation of access in case of myoma in plica vesicouterina. Arrow 2 – lateral posterior retroperitoneal access. UT – uterus; B – bladder; RL– lig. rotundum; ABL, PBL – anterior and posterior retroperitoneal access. The ellipse indicates the localisation of the retroperitoneal myoma.

3.2. Discussion

This approach is used to perform pelvic lymph node dissection and for tumours localised in the pararectal space. After accessing the PVS, we visualise the ureter and cardinal ligament. After the transection of the latter, we engage the PRS and the tumour in the ventral-dorsal direction. We may also use this lateral approach for intraligamentary myomas that do not reach the pelvic wall.

4. Medial anterior retroperitoneal approach

4.1. Results and surgical technique

It was performed on 46 patients. The access was initiated with ligation and transection of lig. rotundum. This was followed by an incision of the anterior leaflet of plica lata in dorso-ventral direction and dissection medially from the lig. umbilicale and laterally from the bladder. After dissection of the ligamentous connective tissue, PVS was medially accessed.

4.2 Discussion

This approach finds application in performing a radical hysterectomy (type C2). It is useful to visualise the upper leaflet of the vesico-uterine ligament and the lateral border of the bladder.

5. Retroperitoneal access in Hudson procedure

5.1. Results and surgical technique

It was performed on 30 patients. Incision of the parietal peritoneum along both paracolic gutters or over the site of peritoneal carcinomatosis was made. The incisions extend caudally to the pelvis along the psoas muscles, displacing anteriorly and medially to the posterior edge of the symphysis. The whole pelvic disease area was surrounded and included within the peritoneal incision. Retroperitoneal ligation and transection of the lig. Rotundum was performed maximally lateral to the pelvic wall. Visualisation of the ureters and ligation of the ovarian vessels was achieved. Accessing PRS and PVS (Figure 3).

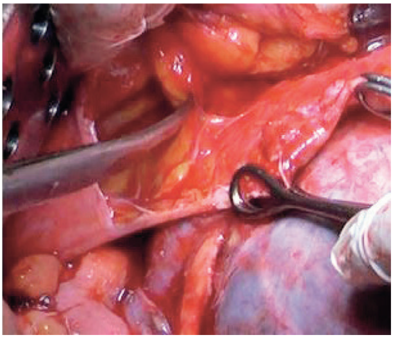

Figure 3. Retroperitoneal access in Hudson procedure (left pelvic wall)

5.2. Discussion

In a large percentage of patients with advanced-stage ovarian carcinoma, we intraoperatively encounter the so-called "frozen pelvis" and carcinomatosis along the pelvic peritoneum. Optimal cytoreduction (R=0) cannot be achieved in these cases by standard total hysterectomy and adnexal surgery. The Hudson procedure aims to achieve optimal cytoreduction and preservation of the rectum/sigma by removing the Douglas peritoneum as a tumour pseudocapsule. The peritoneum is resected along the plica vesicouterina, cavum Douglassi, and part of the rectal wall. In some cases, the surgical intervention is combined with resection of the rectum and/or sigmoid colon, but the main procedure is the retroperitoneal approach. It is necessary to emphasise that we should first evaluate the possibility of optimal cytoreduction in the upper abdomen before proceeding to Hudson surgery.

III.1.2. Extraperitoneal access

1.1. Results and surgical technique

This type of access was performed on 10 patients with cervical carcinoma. Extraperitoneal lymph node dissection was performed in 8 of them. In the remaining 2 cases, extraperitoneal ligation of the hypogastric artery was performed because of profuse genital bleeding from advanced cervical carcinoma.

We executed lower medial skin incision, subcutaneous fat (Camper's and Scarpa's fascia), aponeurosis of m. rectus abdominis. Lateral dissection between the rectus and its aponeurosis followed.

If the rules of dissection and the correct approach are followed, dissection is relatively easy. The blood vessels are coagulated with bipolar forceps. After reaching the parietal peritoneum located after the lateral end of m. rectus abdominis, the dissection continues in a caudal direction, reaching the retroperitoneal space. It is desirable to preserve the integrity of the parietal peritoneum during dissection. Ligation and transection of the lig. rotundum ensures good exposure of retroperitoneal structures – ureters, vessels, m. psoas major.

1.2. Discussion

The extraperitoneal approach provides an opportunity to perform pelvic lymph node dissection and ligation of the HA in cases of profuse genital bleeding and advanced cervical cancer. In many cases of locally advanced malignant processes, the pelvis is completely blocked by the disease, and the only surgical option is via the extraperitoneal approach. Cibula et al. demonstrated that radical hysterectomy should not be performed in the presence of metastatic pelvic lymph nodes, and the patient should be referred for adjuvant radiotherapy. The authors concluded that the survival of the two groups (positive lymph nodes with – group I, or without hysterectomy – group II) was the same, but the morbidity was higher in patients who underwent a radical hysterectomy.

III.2. Avascular pelvic spaces

2.1. Paravesical space

2.1.1 Results

It is reasonable to divide the PVS into lateral and medial because the two vascular-free spaces have different applications in gynaecologic surgery.

The lateral paravesical vascular-free space was developed in 110 patients. The space was applicative bilaterally in 220 cases.

The medial paravesical vascular-free space was reached bilaterally in 90 patients; therefore, it was applicative 180 times

Borders of the lateral PVS:

– Ventrally – linea arcuata of the iliac bone;

– Dorsally – lig. cardinale (parametrium – above the ureter) and paracervical (below the ureter);

– Medially – lig. umbilicale, together with the umbilical prevertebral fascia;

– Lateral – arteria/vena iliaca externa;

– Cranially – parietal peritoneum;

– Caudally – nervus obturatorius.

Borders of the medial PVS:

– Ventrally – ramus superior ossis pubis;

– Dorsally – lig. cardinale (parametrium – above the ureter) and paracervix (below the ureter);

– Medially –bladder;

– Laterally – lig. umbilicale, together with the umbilical prevertebral fascia;

– Cranially – parietal peritoneum;
– Caudally – musculus levator ani.
The two paravesical spaces are represented in Figure 4.

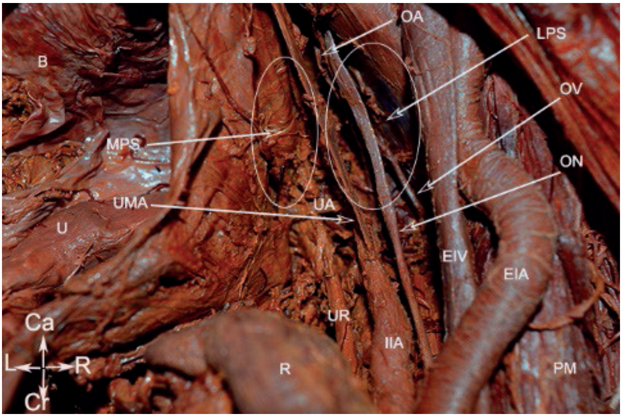

Figure 4. Medial paravesical and lateral paravesical space (right pelvic wall). MPS – medial paravesical space; LPS – lateral paravesical space; ON – nervus obturatorius; OA – arteria obturatoria; OV – vena obturatoria; EIA – arteria iliaca externa; EIV – vena iliaca externa; PM – musculus psoas major; IIA – arteria iliaca interna; UA – uterine artery; UMA – obliterated umbilical artery; R – rectum; B – vesica urinaria, U – uterus; Cr – cranial; Ca – caudal; L – left; R – right

2.1.2. Discussion

The dorsal border of the two spaces should be the cardinal ligament (lateral parametrium) only, but not the uterine artery. The reason is that anatomical variations of the origin of the uterine artery could shift this boundary. Tanchev describes the anatomical variations of this artery in detail. Unlike the artery, the cardinal ligament is a relatively constant anatomical structure and should be the dorsal border.

From a surgical standpoint, the lateral border of the lateral PVS should be arteria/vena iliaca externa, not the fascia of the musculus obturatorius internus. The vessels are medial to the muscle and its fascia, and any lateral dissection (to identify the fascia and muscle) could result in their iatrogenic damage.

The caudal border of the lateral PVS should be the obturator nerve. Further dissection in caudal direction could result in a possible lesion of the underlying obturator artery and vein.

The caudal border of the medial PVS is the levator muscle.

The PVS should not be considered as part of the prevesical area. These are two different spaces with different applications in gynaecologic surgery.

It is reasonable to divide the PVS into two separate spaces since they reflect different uses and can be accessed independently of each other.

In cases of radical hysterectomy without pelvic lymph node dissection, the medial PVS can be accessed independently. The lateral PVS can be reached if only pelvic lymph node dissection is performed.

In the case of vesicovaginal fistula, only the medial and vesicovaginal PVS are dissected. Dissection of the lateral PVS is unnecessary.

2.2. Pararectal space

2.2.1. Results

The pararectal vascular-free space was divided into two vascular-free spaces – lateral and medial.

Borders of the lateral PRS (Latzko's space):

– Ventrally – lig. cardinale;

– Dorsally – the lateral part of the sacral bone;

– Laterally – arteria hypogastrica;

– Medially - ureter.

The space was developed on 115 patients – 230 cases.

Borders of the medial PRS:

– Ventrally – lig. cardinale;

– Dorsally – fascia presacralis, os sacrum;

– Laterally – ureter, mesoureter, nervus hypogastricus;

– Medially – ligamentum sacrouterinum.

The space was developed on 55 patients – 110 cases.

The two spaces are presented on Figures 5 and 6, respectively.

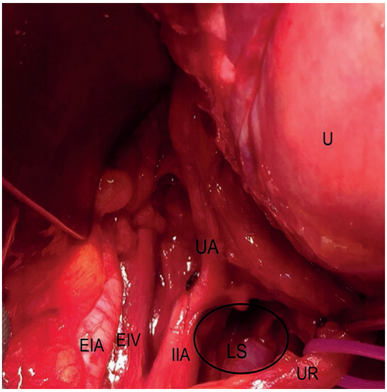

Figure 5. Latzko's space (left pelvic wall). LS – lateral pararectal space; EIA – arteria iliaca externa; EIV – vena iliaca externa; UR – ureter; B – vesica urinaria; UA – arteria uterina; IIA – arteria iliaca interna; U – uterus

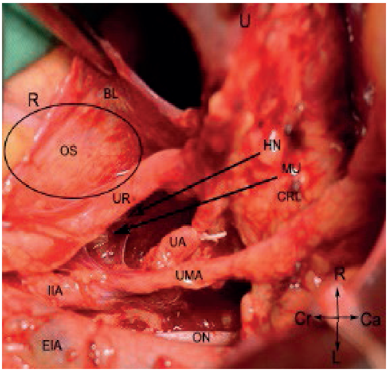

Figure 6. Okabayashi's pararectal space of (left pelvic wall). U – uterus; UR – ureter; EIA – arteria iliaca externa; IIA – arteria iliaca interna; ON – nervus obturatorius; CRL – lig. cardinale; UA – arteria uterina; UMA – arteria umbilicalis; OS –Okabayashi's space; HN – nervus hypogastricus; MU – mesoureter; R – rectum; BL – posterior leaflet of plica lata and sacrouterine ligament; Cr – cranial; Ca – caudal; L – left; R – right

2.2.2. Discussion

The main questions here are regarding the medial border of the Okabayashi's space. The medial border of this space is the sacrouterine ligament, not the rectum. The reason is that lig. sacrouterinum is the lateral border of the rectovaginal space; defining the rectum as the medial border of Okabayashi's space leads to an unnecessary fusion of the two spaces.

The anatomical structure separating the two spaces is the ureter. It is the medial border of the lateral PRS. However, the lateral border of the medial PRS should also be the mesoureter, along with its accompanying hypogastric nerves. The reason is that the purpose of dissection of Okabayashi's space is to dissect and mobilise the hypogastric nerves because when the dissection is performed, they get separated together with the ureter and mesoureter and automatically become lateral border of the dissection.

Another important detail of discussion that has not been addressed so far in the world medical literature is a dissection of the medial PRS when performing the Hudson procedure. The Hudson procedure has also been called "radical ovariectomy", but this does not mean that pelvic innervation should not be preserved. Unlike standard radical hysterectomies, we do not ligate the cardinal ligament to the pelvic wall or sever the vesicouterine ligament. For this reason, we need to dissect Okabayashi's space to visualise the hypogastric nerves and supply them when performing radical ovariectomy.

2.3. Medial psoas space (dissection plan)

2.3.1. Results

This is a surgical vascular-free space but a rather different dissection plan to the obturator fossa. The space was developed on 25 patients – 50 cases.

Borders:

– Cranially – the peritoneum covering the arteria/vena iliaca externa and m. psoas major;

– Caudal – nervus obturatorius;

– Ventrally – vena circumflexa iliaca profunda;

– Dorsally – the point of bifurcation of the arteria iliaca communis;

– Laterally – m. psoas major;

– Medially – arteria/vena iliaca externa;

It is presented on Figure 7.

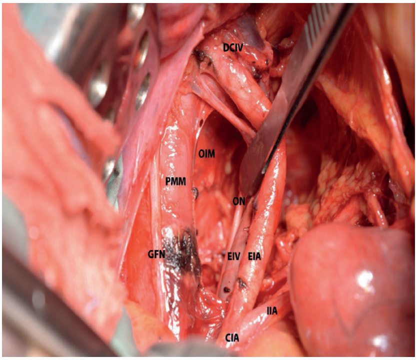

Figure 7. Vascular-free plan of dissection medial to musculus psoas major (left pelvic wall). CIA – arteria iliaca communis; EIA – arteria iliaca externa; EIV – vena iliaca externa; ON – nervus obturatorius; GFN – nervus genitofemoralis; PMM – musculus psoas major; OIM – musculus obturatorus internus; DCIV – deep circumflex iliac vein; IIA – arteria iliaca interna

2.3.2. Discussion

This dissection plan finds many gynaecological applications: pelvic lymph node dissection, laterally extended endopelvic resection, removal of recurrences or tumours involving the pelvic wall, and ligation of the HA. Additionally, the space allows access to the pelvic nerves compartment and aids in the treatment of deep pelvic endometriosis involving the lumbosacral trunk and anterior branches of the sacral nerves. Separately, we use this dissection plan when the paravesical space is involved and the obturator nerve cannot be visualised. This approach is a different way to reach the obturator fossa and allows for easier visualisation of the nerve.

2.4. Vascular-free space in ureteral tunnelling

2.4.1. Results

The space was developed on 82 patients (164 cases).

Borders:

– Laterally – ligamentum cardinale (lateral parametrium);
– Medially – uterine cervix, vagina;
– Ventrally – arteria uterina;
– Dorsally – vena uterina profunda;
– Cranially – ureter.

2.4.2. Discussion

The space is mainly used in radical hysterectomy to free the ureter from the cardinal ligament. Additionally, this space was developed on 30 patients who underwent Hudson surgery. The purpose of this dissection was to free the ureter from the cardinal ligament. Thus, the ureter is under continuous visualisation and control during retrograde ligation of the sacral ureteric and cardinal ligaments.

The space was also accessed in 4 patients with intraligamentous myomatous nodules in plica lata and 2 patients with cervical myomas. Because this type of myoma nodules significantly alters the topographic anatomy of the ureter, visualisation is necessary to enucleate the myoma nodules.

5. Paravaginal Okabayashi space

2.5.1. Results

It was developed in 2 patients bilaterally (4 cases).

Borders:

– Laterally – ureter, lower leaflet of ligamentum vesicouterinum;

– Medially – vagina;

– Ventrally – upper leaflet of ligamentum vesicouterinum;

– Dorsally – PVS;

– Cranially – the distance between the paracolpium and the lower leaflet of ligamentum vesicouterinum;

– Caudally – bladder.

2.5.2. Discussion

The paravaginal Okabayashi space is applicative in performing type C1/C2 radical hysterectomy, as well as in treating deep pelvic endometriosis.

2.6. Yabuki space (the Fourth space)

2.6.1. Results

It was developed bilaterally in three patients (6 cases) – as per the new definition.

Borders:

– Laterally – medial PVS;

– Medially – vaginal wall and the medial half of the lower leaflet of ligamentum vesicouterinum;

– Ventrally – upper leaflet of lig. vesicouterinum;

– Dorsally – PVS;
– Cranially – ureteral tunnel;
– Caudally – bladder.

2.6.2. Discussion

The space is applicative in performing a nerve-sparing hysterectomy (C1/C2) or in treating deep pelvic endometriosis. The new definition of the two spaces is complex and would lead to further confusion for gynaecologic oncologists. It is more logical to use the old definition.

2.7. Prevesical (retropubic, Retzius space)

2.7.1. Results

The prevesical space was dissected in 4 cadaveric dissections and 6 patients.

Borders:
– Ventrally – symphysis;
– Dorsally – parietal peritoneum;
– Cranially – fascia umbilicalis vesicalis;
– Caudally – initial part of the urethra, fascia pubocervicalis, bladder neck.

It is shown on Figure 8.

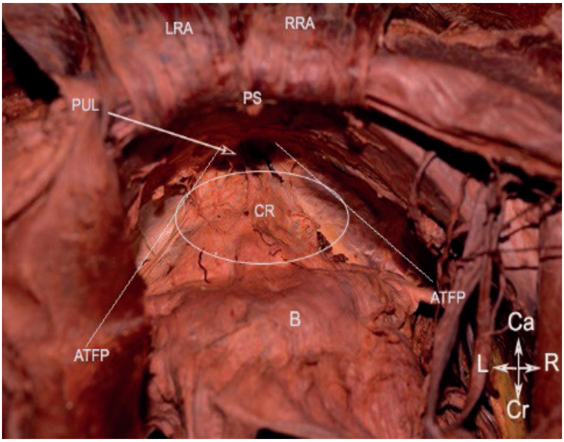

Figure 8. Prevesical vascular-free space. CR – Cavum Retzii; ATFP – arcus tendineus fascia pelvis; LRA/RRA – left/right rectus abdominis muscle; PS – symphysis; B – bladder; PUL – ligamentum pubourethralis

2.7.2. Discussion

The prevesical space should not be considered part of the paravesical space. This would only confuse gynaecologists, urologists and surgeons, as both spaces have different uses in different surgical disciplines. For this reason, the lateral border of Retzius space is arcus tendineus fascia pelvis, not the lig. umbilicale.

The dorsal border of the space is the parietal peritoneum, not the visceral fascia of the bladder, because it lies beneath the adjacent peritoneum.

Many authors discuss the cranial border of the retropubic space and conclude that this should be fascia transversalis. However, the authors do not mention that there are other fascial sheets in this space besides fascia transversalis: fascia umbilicalis vesicalis and fascia umbilicalis prevesicalis. In the dissection of the retropubic space, the umbilical fascia of the bladder is the first fascial layer to be dissected; it should be considered the cranial border of this space. Some authors argue that the prevesical space should be dissected during Hudson's surgery. The prevesical space is not dissected in Hudson surgery. The dissection plan is between the bladder detrusor and the parietal peritoneum; the retropubic space is not within the operative field. Additionally, the development of this space in Hudson surgery is unnecessary as it may cause bleeding from the blood vessels located there, their branches and anastomoses – Santorini veins, the dorsal vein of the clitoris, anastomoses between obturator vessels, arterial and venous branches of arteria pudenda interna.

2.8. Vesico-cervical/vesicovaginal space

2.8.1. Results

Both spaces were dissected in 107 patients.

Anatomical boundaries of the vesico-cervical space:

– Ventrally – visceral fascia of the bladder;
– Dorsally – fascia pubocervicalis; cervix
– Laterally – upper leaflet of ligamentum vesicouterinum;
– Cranially – the peritoneum covering the bladder.

Anatomical boundaries of the vesicovaginal space:

– Ventrally – the trigone of the urinary bladder;
– Dorsally – fascia pubocervicalis; anterior vaginal wall;

– Laterally – upper leaflet of ligamentum vesicouterinum;
– Cranially – the peritoneum covering the bladder;
– Caudally – the beginning of the lower third of the urethra.

It is presented on Figure 9.

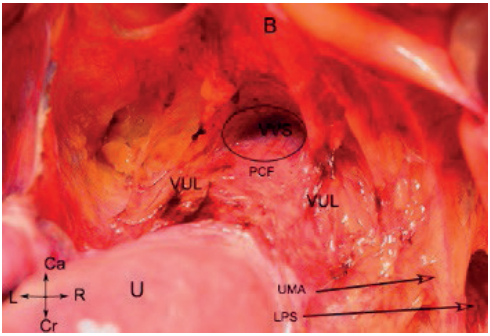

Figure 9. Boundaries of the vesicovaginal vascular-free space. B – bladder; VUL – upper leaflet of the vesico-uterine ligament; PCF – fascia pubocervicalis; U – uterine body; VVS – vesicovaginal space; LPS – lateral paravesical space; UMA – umbilical artery

2.8.2. Discussion

The two spaces are some of the most commonly dissected in the gynaecologic practice. Hence, they are well-studied, and there is no controversy in the medical literature regarding their boundaries. What can be added to it are the rules regarding their dissection. It is essential that the dissection is performed over fascia pubocervicalis. Any change in this plan would result in bleeding in the operative field. The rule that the adipose tissue belongs to the bladder should not be forgotten. If possible, it is desirable to start the dissection medially and then laterally to the upper leaflets of lig. vesicouterinum. Lateral initiation of dissection may result in lesions of the blood vessels or ureters.

2.9. Rectovaginal space

2.9.1. Results

The rectovaginal space was dissected in 88 patients with a medial approach. The lateral approach was used in 2 patients with deep pelvic endometriosis.

Borders:

– Ventrally – visceral fascia of the posterior vaginal wall;

– Dorsally – visceral fascia of the anterior rectal wall;

– Laterally – lig. sacrouterinum;

– Caudally – musculus levator ani;

– Cranially – the peritoneum covering the Douglas space.

2.9.2. Discussion

Our literature review shows much controversy regarding the existence of the Denonvilliers' fascia among the female sex. Further anatomical and surgical studies are necessary to prove its existence and possible topographical anatomy. The critical point, in this case, is that there is a vascular-free approach between the fascia of the anterior rectal wall and the fascia of the posterior vaginal wall. Gynaecologists should follow this approach to avoid bleeding. Therefore, the ventral and dorsal borders of the rectovaginal vascular-free space should be the fascia of the anterior rectal and posterior vaginal walls, respectively. The basic rule of dissection is that the adipose tissue belongs to the rectum. To avoid rectal lesions or bleeding, gynaecologists should follow the above-mentioned dissection rules. Bleeding may occur in case of blood vessel laceration near this space – the meddle rectal artery/vein and the vaginal vein.

2.10. Presacral (retrorectal) space

2.10.1. Results

The presacral space was dissected in 50 patients and 4 cadaveric dissections.

Borders:

– Ventrally – fascia mesorectalis, rectum;

– Dorsally – lig. longitudinale anterius, sacrum, promontorium;

– Laterally – left – vena iliaca communis sinistra; right – arteria iliaca communis dextra/ hypogastric fascia formed by the medial fibres of the two sacrouterine ligaments;

– Cranially – the peritoneum covering the rectum/sigma;

– Caudally – pelvic floor.

It is represented on Figure 10.

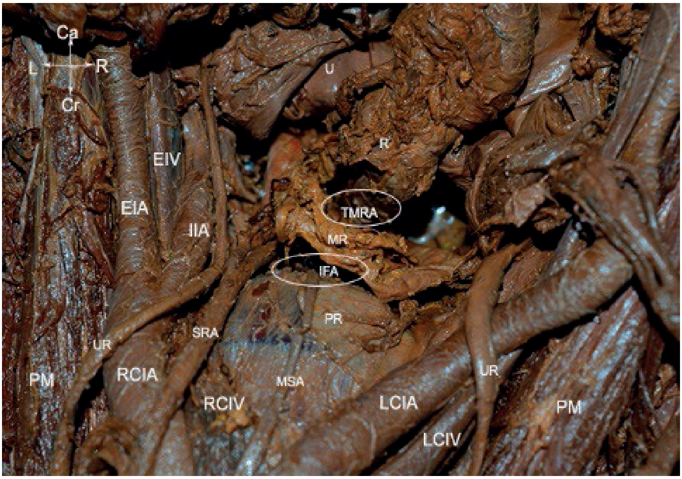

Figure 10. Presacral vascular-free space. R – rectum; U – uterine body; PM – musculus psoas major; RCIA – arteria iliaca communis dextra; RCIV – vena iliaca communis dextra; LCIV – vena iliaca communis sinistri; LCIA – arteria iliaca communis sinistri; UR – ureter; IIA – arteria iliaca interna; SRA – arteria rectalis superior; PR – promontory; MSA – arteria sacralis media; MR – mesorectum; TMRA – transmesorectal access; IFA – interfascial access

2.10.2. Discussion

The retrorectal space is less used by gynaecologists because of its more complex anatomy and the presence of large blood vessels that are its lateral borders. Additionally, presacral lymph node dissection is not widely used in gynaecologic malignancies and is avoided by many gynaecologic oncologists. Here we present two plans of dissection. The first is the transmesorectal, which preserves the mesorectum; we use it in cases of deep pelvic endometriosis. The second is the interfascial plan (also known as the “Holy plane” among fellow surgeons), in which the surgeon removes the mesorectum. We use this approach in Hudson surgery.

III.3. Anatomy of the pelvic and paraaortic lymph nodes

3.1. Pelvic lymph nodes

3.1.1. Results

The topographic anatomy around the pelvic lymph nodes was studied in 65 patients – 129 pelvic walls.

We divide the pelvic lymph nodes into the following groups:

1. Common iliac lymph nodes;
2. External iliac lymph nodes;
3. Internal iliac lymph nodes;
4. Obturator lymph nodes;
5. Paracervical lymph nodes (anatomically – as they are located in the small pelvis);
6. Sacral lymph nodes.

3.1.2. Discussion

Cervical lymph nodes drain primarily into the obturator lymph nodes. Metastases to these lymph nodes are most common in malignancies of the uterus and its appendages. Therefore, the subset of obturator lymph nodes should be considered a separate group of lymph nodes.

Since the adoption of a newly revised classification of radical hysterectomy, the question arises of a subgroup of lymph nodes, specifically, the paracervical. The dissection of these lymph nodes discriminates between B1 and B2 according to the Querleu–Morrow classification. The issue is how exactly to define these lymph nodes since there is much controversy. We have defined the term "paracervical" as the connective tissue structure lying under the ureter and connecting the uterine cervix and the pelvic wall. Therefore, it is part of the cardinal ligament. The anatomical structure located above the ureter is called the parametrium. The ureter divides the paracervical into two parts: medial (primarily connective tissue) and lateral (containing paracervical lymph nodes). Nervus obturatorius is the anatomical structure that differentiates the pelvic lymph nodes from the paracervical ones. The latter are localised in the paracervical, medial and cranial to the nerve and lateral to the ureter. We defined the paracervical lymph nodes as part of the lymph nodes of the uterus and its appendages. We defined them as the border between the pelvic lymph nodes and those of the uterus and its appendages. According to anatomical classification, they can be considered pelvic because they are located in the small pelvis, but from a surgical standpoint, they should not be considered part of the pelvic lymph nodes (Figure 11).

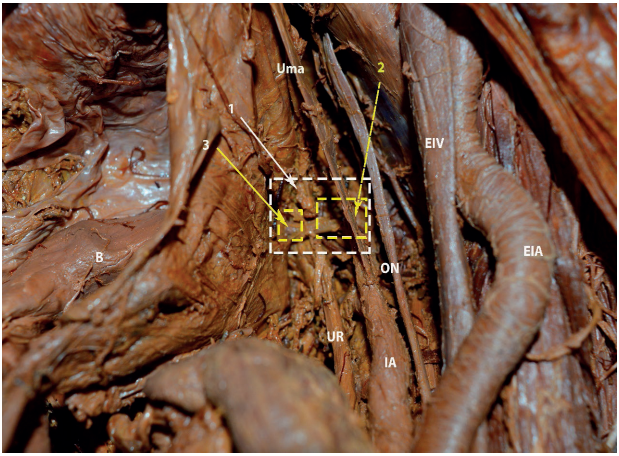

Figure 11. Paracervical lymph nodes. 1) white rectangle – reflects the volume of dissection of the paracervical lymph nodes in hysterectomy type B2 (medially and caudally to the obturator nerve); 2) the larger yellow rectangle – lateral part of the paracervix; 3) the smaller yellow rectangle -medial part of the paracervix.

EIA – external iliac artery; EIV – external iliac vein; UR – ureter; B – bladder; IA – hypogastric artery; ON – obturator nerve; Uma – the obliterated umbilical artery

3.2. Paraaortic lymph nodes

3.2.1. Results

The topographic anatomy surrounding the paraaortic lymph nodes was studied in 27 patients.

We divided the paraaortic lymph node dissection into anatomical zones (Figure 12):

– Supra-mesenteric – above the a. mesenterica inferior

Borders: superiorly – left RV; medially – AA; laterally – ureter and Gerota fascia; inferiorly – inferior mesenteric artery; caudally – psoas muscle;

– Inframesenteric – below a. mesenterica inferior

Borders: superiorly – inferior mesenteric artery; medially – AA; inferiorly – left common iliac artery; laterally – ureter and Gerota fascia; caudally – psoas muscle;

– Aortocaval – between AA and IVC

Borders: superiorly – left RV; laterally – left lateral AA; right – the lateral part of IVC; caudally – prevertebral fascia, ligamentum longitudinal anterior, musculus psoas major; inferiorly – AA bifurcation;

– Paracaval – laterally and below IVC

Borders: superiorly – right RV; inferiorly – mid-lateral portion of the right common iliac artery; laterally – right ureter and right psoas muscle; caudally – right psoas muscle.

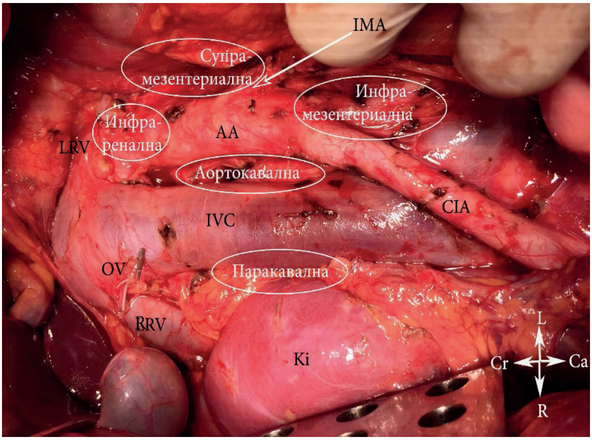

Figure 12. Zones of paraaortic lymph node dissection. AA – Abdominal aorta; IVC – inferior vena cava; CIA – common iliac vein; LRV– left renal vein; RRV – right renal vein; IMA – inferior mesenteric artery; Ki – kidney; OV – ovarian vein

3.2.2 Discussion

Similar to the vascular-free spaces, the zones benefit more precise dissection in the paraaortic region. No intraoperative complications were observed among patients operated on by zone shape optimisation.

III.4. Retroperitoneal anatomy of the ureter

4.1. Results

Retroperitoneal ureteral anatomy was studied in 220 ureters.

To understand in detail the retroperitoneal anatomy of the ureter and its significance in gynecologic surgery, we divided it into 5 zones:

Zone 1 – *the Golden Triangle*;

Zone 2 – the area between Zone 1 and the ureter's point of entry into the small pelvis (up to the AA bifurcation);

Zone 3 – the area between the ureter's point of entry into the small pelvis and before its entry into the cardinal ligament;

Zone 4 – the localisation of the ureter in the cardinal ligament;

Zone 5 – the localisation of the ureter between the leaflets of the vesicouterine ligament.

4.2. Discussion

Zone 1 – *The Golden Triangle*

This zone has been described in surgical procedures related to kidney transplantation. However, it is also of great importance in gynaecologic oncology surgery, particularly when performing paraaortic lymph node dissection. Zone 1 begins immediately where the ureter leaves the renal hilus and is surrounded by the inferior portion of the left kidney and the junction of RV to IVC. The inferior polar RA (if present) and the ovarian vein fall within this zone. The Golden Triangle is delineated as a separate zone because it contains important arterial branches (a common anatomic variation – inferior polar RA) that supply blood even to the proximal part of the ureter. It is crucial not to dissect this zone and to preserve the peri-ureteral connective tissue. Oncologists should also avoid this area during paraaortic lymph node dissection (Figure 13).

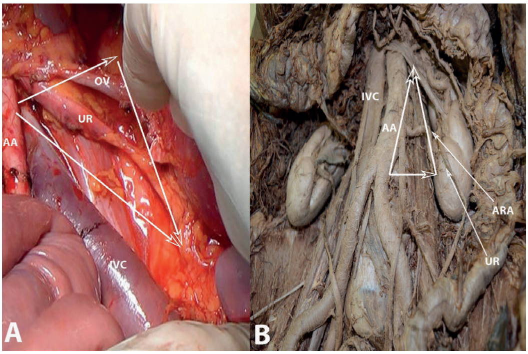

Figure 13. Zone 1. A – Zone 1 in dissection of the caval lymph nodes (arrows point cranially). B – Zone 1 on the left in cadaveric dissection. AA – abdominal aorta; IVC – inferior vena cava; UR – ureter; ARA – additional inferior polar aorto-renal artery in the area of Zone 1; OV– right ovarian vein

Zone 2

This zone is dissected when performing a paraaortic lymph node dissection in order to keep the ureter under continuous visual control during the procedure. Additionally, it can be resected during ligation and transection of the ovarian vessels. In a total hysterectomy, this is executed in its middle part (immediately before entering the small pelvis). In paraaortic lymph node dissection, this is done in the proximal part as it is desirable to ligate the ovarian veins immediately at their inflow into the left RV (left) and IVC (right). Preserving the blood supply to the ureter from the AA or its branches is advisable.

Zone 3

In this zone, the ureter serves primarily as a landmark dividing the PRS into two additional spaces – the Latzko's and Okabayashi's spaces. The urinary tract also guides us for the location of the hypogastric nerves, located in the mesoureter and 2–3 cm caudally to the ureter. While it is the medial border of Latzko's space, in Okabayashi's space, the ureter, along with the mesoureter and hypogastric nerves, is the lateral border. If not identified and mobilised in this area, the ureter can be damaged when performing pelvic lymph node dissection – especially when removing the obturator, internal iliac and sacral lymph nodes. Ureteric damage can also be seen in Hudson surgery during surgical treatment of deep pelvic endometriosis and retroperitoneal myomas of the PRS. Attention should be paid to the small arterial branches to the ureter – from the HA, the ovarian artery, and the middle rectal artery.

Zone 4

The delineation of a separate Zone 4 in the cardinal ligament is due to the following reasons that we have identified:

– The ureter divides the paracervix (part of lig. cardinale) into two, a medial and a lateral part. The medial part contains connective tissue fibres, whereas the lateral part is where the paracervical lymph nodes are localised. This is particularly important, especially after the adoption of the newly revised classification of radical hysterectomy.

– A new vascular-free space is also found here – the space at the ureteric tunnelling;

– This area is invariably associated with the performance of radical hysterectomy;

– Nerve branches of the inferior hypogastric plexus innervating the bladder pass through this area immediately below the deep uterine vein. Dissection of the cardinal ligament to the level of the inferior uterine vein is the basis of nerve-sparing radical hysterectomy;

– Arteria in T is localised immediately in this zone;

– In Hudson surgery, we dissect part of the cardinal ligament and tunnel the ureter.

The rate of ureteral damage is relatively high in this area. Avoidance of electrocoagulation devices with local heating is desirable because they can lead to thermal damage to adjacent tissues and particularly the ureter. Attention should be paid to the corresponding small arterial branches to the ureter – a. vaginalis branch and a. vesicalis inferior.

Zone 5

Zone 5 has been indicated as a separate zone due to the following reasons that we have identified:

– It is involved in the formation of the two vascular-free spaces located between the two leaflets of the vesicouterine ligament – the Latzko's and Okabayashi's pararectal spaces;

– Many branches of the corresponding arteries and veins – the uterine artery, vaginal artery, and superior and inferior vesical arteries, pass into the two leaflets of the vesico-uterine ligament. The presence of many anastomoses between the aforementioned arteries/veins has also been observed. This area is of greatest importance when performing a radical hysterectomy type C2. It is often associated with profuse bleeding and iatrogenic lesions of the ureter resulting from attempts to control the bleeding.

– Proper dissection of the vascular-free spaces and isolation of the ureter prevents excess bleeding.

– The extent of resection of the vesicouterine ligament (along with the cardinal and sacrouterine ligaments) determines the type of radical hysterectomy.

– The nerve endings of the inferior hypogastric plexus that innervate the bladder pass through this zone.

– The zone is associated with the highest rate of ureteral damage (ureterovaginal, uretero-ureteral, and vesicovaginal fistulas are characteristic of this zone), which can be prevented with detailed knowledge of the anatomy and precise dissection.

Zone 5 is presented in Figure 14.

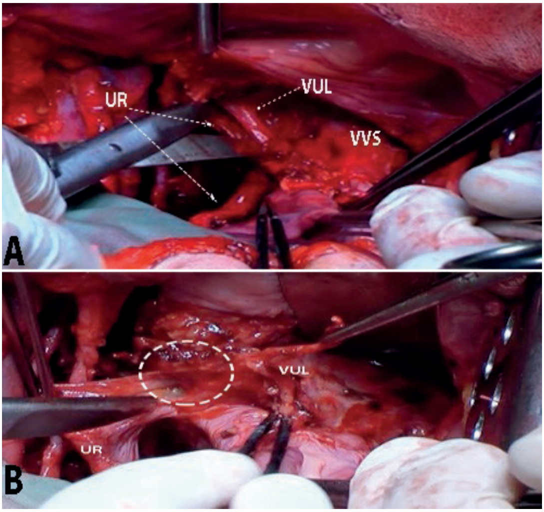

Figure 14. Zone 5. Dissection of the ureter from the upper leaflet of the vesicouterine ligament (A, B). VUL – upper leaflet of the vesicouterine ligament; UR – ureter; VVS – vesicovaginal space

III.5. Corona mortis, aberrant obturator vessels, accessory obturator vessels:

5.1. Results

Corona mortis, aberrant and accessory obturator vessels were visualised in 19, 9 and 28 cases, respectively.

We defined the relevant anatomical structures as follows:

Corona mortis is any abnormal anastomosing vessel (localised posterior to the superior pubic ramus and posterior to lig. lacunare) that accomplishes anastomosis between the obturator vessels and the external iliac vessels, as well as their branches. The anastomosing vessel must be more than 2 mm to be defined as a “Corona mortis” (Figure 15).

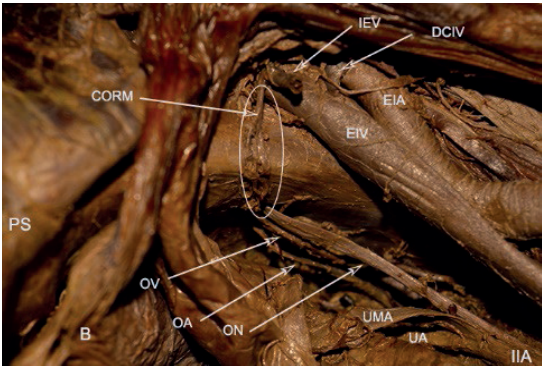

Figure 15. Corona mortis – venous anastomosis between the obturator and inferior hypogastric vein (right pelvic wall). CORM – corona mortis; ON – nervus obturatorius; OA – arteria obturatoria; OV – arteria obturatoria; DCIV – deep circumflex iliac vein; B – bladder; PS – symphysis; IIA – arteria iliaca interna; UA – arteria uterina; UMA – umbilical artery; IEV – vena epigastrica inferior; EIA/ EIV – external iliac artery/ external iliac vein

An aberrant obturator vessel is defined as any vessel originating from the external iliac vessels or their branches and passing through the obturator canal, not involving or forming anastomoses. No other obturator vessel is present (Figure 16).

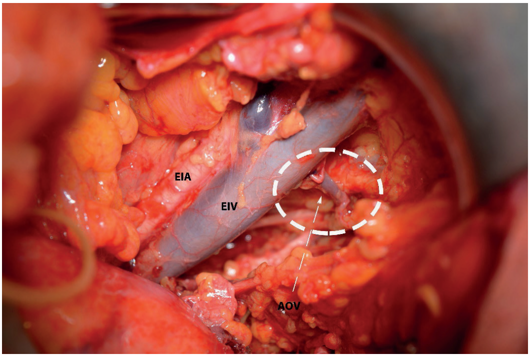

Figure 16. Aberrant obturator vein (left pelvic wall). EIA/EIV – external iliac artery/ external iliac vein; AOV – aberrant obturator vein

An accessory obturator vessel is defined as any additional obturator vessel and must have a normal obturator vessel. The accessory obturator vessel passes through the obturator canal without participating in the formation of anastomoses with other vessels.

Based on anatomical and surgical studies, we classified the Corona mortis, aberrant obturator vessels, and accessory obturator vessels (Figures 17, 18, 19).

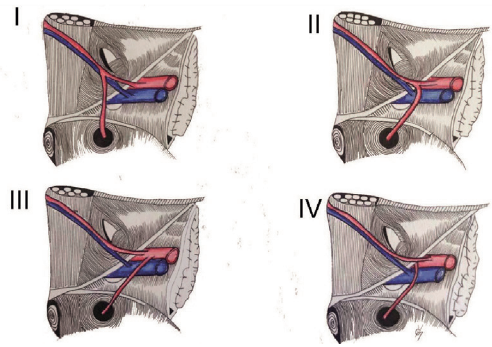

Figure 17. Classification of aberrant obturator arteries

Type I – AOA originating from a. epigastrica inferior. The AOA is localised medially to the deep femoral ring. Type II – AOA originating from a. epigastrica inferior. AOA is localised laterally to the deep femoral ring. Type III – AOA originating from a. iliaca externa. Type IV is originating from a. femoralis

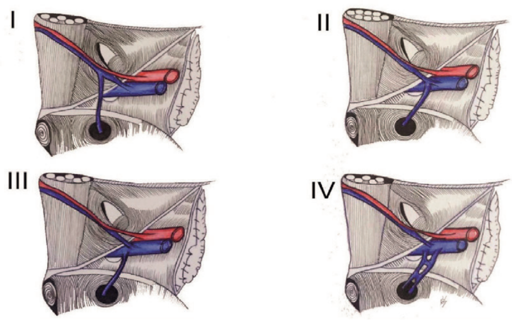

Figure 18. Classification of aberrant obturator veins

Type I - AOV drains into v. epigastrica inferior and is located medial to the femoral ring. Type II - AOV drains into v. epigastrica inferior and is lateral to the femoral ring. Type III - AOV drains into the v. iliaca externa. Type IV - double obturator vein draining into v. iliaca externa. It is located medial to the femoral ring.

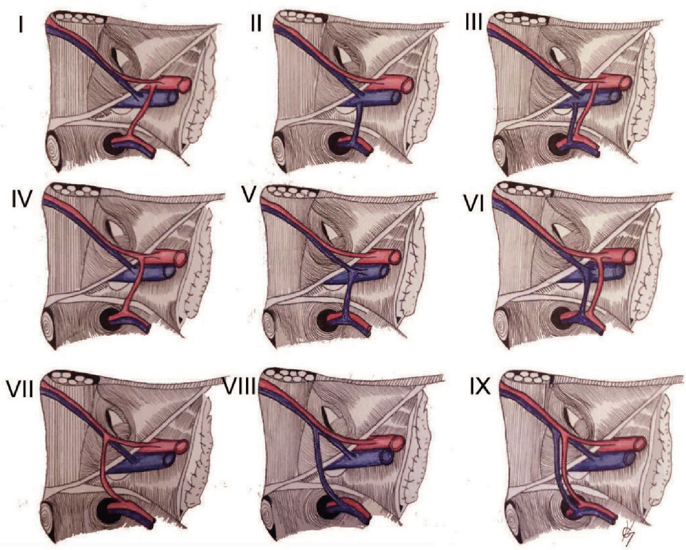

Figure 19. Classification of Corona mortis

Type – CMOR between a. obturatoria and a. iliaca externa. Type II – CMOR between v. obturatoria and v. iliaca externa. Type III – CMOR between the obturator and external iliac vessels (artery and vein). Type IV – CMOR between a. epigastrica inferior and a. obturatoria. Type V – CMOR between v. epigastrica inferior and v. obturatoria. Type VI – CMOR between the obturator and superior epigastric vessels (artery and vein). Types IV, V, and VI are lateral to the femoral ring. Type VII – CMOR between a. epigastrica inferior and a. obturatoria. Type VIII – CMOR between v. epigastrica inferior и v. obturatoria. Type IX – CMOR between the obturator and inferior epigastric vessels (artery and vein). Types VII, VIII and IX are located medially to the femoral ring.

5.2. Discussion

Based on the classification, anatomical dissections and surgical interventions, we came to the following conclusions:

5.2.1 Iatrogenic lesion during pelvic lymph node dissection

Selcuk et al. conclude that the term CMOR is debatable. They find that this vascular abnormality is easy to visualise. Precise dissection in the region of the external iliac artery and around the inguinal ligament would not result in a lesion of CMOR. The authors reported 6 CMOR lesions among 96 pelvic lymph node dissections. Other authors are of the opposite opinion.

The truth is somewhere in between the two authors' opinions. There is a small risk of CMOR lesion during lymph node dissection in the region of a. et v. iliaca externa in CMOR between a. et. v. epigastrica inferior and a. et v. obturatoria. This is because the ventral border of a pelvic lymph node dissection is v. circumflexa iliaca profunda, located approximately 1 cm proximally to a. epigastrica inferior. This avoids dissection close to a. epigastrica inferior and, therefore, to a CMOR lesion between the epigastric and obturator vessels. A lesion here is more likely to be of an aberrant or accessory obturator vessel because these vessels are more likely to be located proximally to v. iliaca circumflexa profunda and laterally to the femoral ring. Laceration of these vessels is associated with more profuse bleeding than in a CMOR lesion because these vessels are larger in diameter than the "necklace of death."

Lesions are also possible in CMOR between the external iliac artery/vein and the obturator artery/vein because this CMOR is localised laterally to the femoral ring and crosses the dissection field.

There is a high possibility of laceration of an aberrant, accessory vessel or CMOR during dissection of the obturator lymph nodes group because these abnormal vessels often have a vertical course, they are located medially to the femoral ring, and fall within the operative field of dissection. The borders of lymph node dissection in the obturator region are: cranially – the caudal part of the external iliac vessels; caudally – the obturator vessels; inferiorly – the superior lateral part of the pubic bone where the obturator nerve leaves the small pelvis and enters the obturator canal; superiorly – the bifurcation of the common iliac vessels.

AOA originating from the femoral artery is associated with a high risk of iatrogenic injury during superficial and deep inguinal lymph node dissection. The sentinel lymph node in vulvar carcinoma is most commonly the Cloquet's node.

The AOA, which originates from the femoral artery, the medial circumflex femoral artery, or the deep femoral artery, may be injured during Cloquet's node dissection. The node is most commonly located medially to the AOA originating from the femoral artery.

5.2.2 Iatrogenic lesion in urogynecological procedures

In urogynecology, anomalous obturator vessels can be damaged most commonly during surgical interventions for correction of stress incontinence – such as Burch colposuspension suprapubic and transobturator sling placement. The possibility of a lesion of these three types of abnormal obturator vessels is greater if they are medial to the femoral ring.

The explanations established in the anatomy room are as follows:

– Lig. pectineale, also known as Cooper's ligament, is located medially to the femoral ring.

– The direction and movement of the needles used to insert suprapubic and transobturator slings are often medial to the femoral ring.

III.6. Variations of vena iliolumbalis and v. lumbalis ascendens

6.1. Results

The incidence of anatomical variations of VLA and VIL was studied in 12 patients who underwent pelvic lymph node dissection. The surgical procedure started with dissection of the medial psoas space (dissection plan medially to the psoas muscle) and dissection of the pelvic wall lymph nodes and the obturator nerve. Using this approach, we noted variations of the above-described veins draining into the external iliac vein. These veins were often noticed immediately after the start of dissection. In all 12 patients, the dissection was performed bilaterally; therefore, drainage variations of VLA and VIL were examined on 24 pelvic walls.

6.2. Discussion

Drainage variations of both veins were observed in 50% of the patients studied. Two patients (16.6%) had bilateral variations. The overall percentage of variations among the 24 pelvic walls was 33.3% (8 pelvic walls), of which 16.6% (4 pelvic walls) had one anomalous vein draining into the external iliac vein, in 8.3% (2 pelvic walls) of the cases two anomalous veins drained into the external iliac vein. In one case (4.1%), we noted three anomalous veins draining into the external iliac vein. No complications were observed during pelvic lymph node dissection.

Although the study included a small number of cases, its significance should be highlighted because 50% of the patients had at least one venous variation in this area. Some anomalous venous vessels were of a non-small diameter, and laceration of some of these would be associated with extensive bleeding. Bleeding in this area is more challenging to control because the vessels may contract against the pelvic wall. Unfortunately, we can only speculate which of the anomalous veins are VLA and VIL, as we need to know their cranial course and drainage. However, such dissection would be unnecessary and life-threatening to the patient. The critical point, in this case, is that these variations exist and are not of low frequency. Gynaecologic oncologists should always be aware of their possible presence when performing surgical interventions in this area (Figures 20, 21).

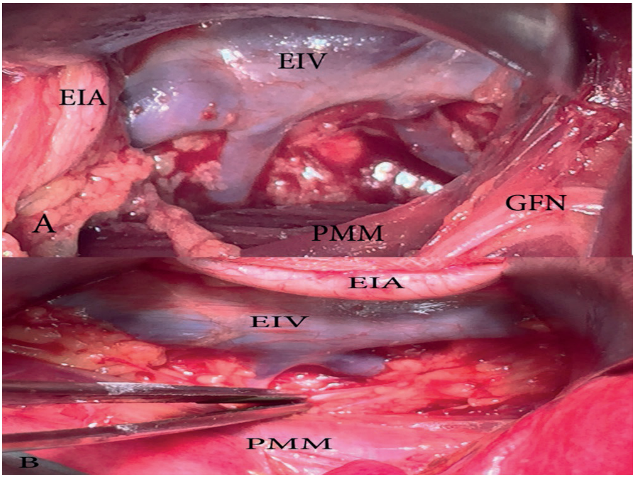

Figure 20. A – two anomalous veins draining into v. iliaca externa (right pelvic wall). B – two anomalous veins draining into v. iliaca externa as a common trunk (right pelvic wall). EIA/EIV –arteria et vena iliaca externa; nervus genitofemoralis; PMM – musculus psoas major

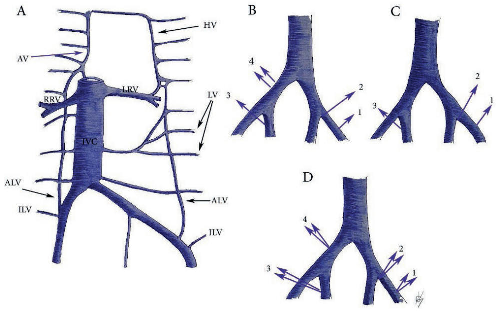

Figure 21. Anatomy (A) and VLA and VIL variations (B, C, D). HV – hemiazygos vein, LV – lumbar veins, ALV – ascending lumbar vein, ILV – iliolumbar vein, IVC – inferior vena cava, LRV – left renal vein, RRV – right renal vein, AV – azygos vein. 1, 2, 3 and 4 show the different drainage abnormalities of VIL (B) and VLA (C).

The draining of both veins under a common trunk is presented on Figure D.

III.7. Anatomical variations in the retroperitoneum and their relation to gynaecological surgery

7.1. IVC variations

7.1.1. Results

Intraoperatively, no IVC variations were found. One variation (double IVC) was observed at anatomical dissection (Figure 22).

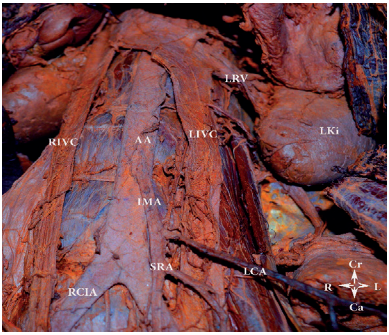

Figure 22. Double inferior vena cava. LIVC – left inferior vena cava; DIVC – right inferior vena cava; AA – abdominal aorta; IMA – inferior mesenteric artery; SRA – arteria rectalis superior; LCA – arteria colica sinistri; RCIA – arteria communis dextra; LRV – left renal vein; LKi – left kidney

7.1.2. Discussion

Anatomically, IVC variations can be divided into the following groups:

A) Left IVC – the second most common anatomical variation of IVC with a frequency of 0.2 to

0.5%;

B) Double IVC – the most common anatomic variation with an incidence of 0.2 to 3%. Left

IVC usually drains into the left RV located anterior to the AA;

C) Left IVC with regressed right IVC – an extremely rare anomaly. Fewer than 10 cases have been described worldwide;

D) Ipsilateral double IVC – a rare anomaly in which a double IVC is located to the left or right of the AA;

E) Marsupial IVC – About 20 cases have been described worldwide in the human population.

On preoperative imaging, IVC may be confused with lymphadenopathy, dilated ureter, small bowel loops or retroperitoneal cystic formations. IVC with interiliac anastomoses can be lacerated during lymph node dissection in any region of the paraaortic lymph node dissection.

Although no IVC variations were observed, a classification of the variations of double IVC was created according to their importance in gynaecologic surgery (Figure 23).

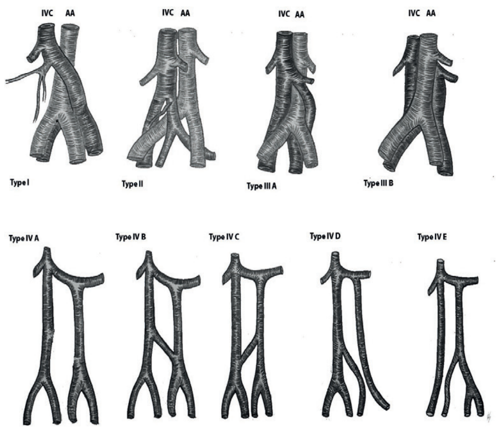

Figure 23. Double IVC

Type I – left IVC with regressed right IVC.

Type II – ipsilateral IVC. The ovarian vein drains into the ventral IVC.

Type III – IVC is localised anterior or posterior to the AA. The left IVC drains into the right.

Type IIIA – anterior to the AA; the left IVC drains into the right at the level of the left RV.

Type IIIB – localised posterior to the AA.

Type IV – left IVC drains into the left RV.

Type IVA – no venous anastomoses between the two veins.

Type IVB – interiliac anastomosis between the two veins from the left common iliac vein.

Type IVC – interiliac anastomosis between the two veins from the right common iliac vein.

Type IVD – interiliac anastomosis between the two veins from the left HV.

Type IVE – interiliac anastomosis between the two veins of the right HV

7.2. Variations of the renal arteries

7.2.1. Results

Intraoperatively, no variations of accessory renal arteries were observed. There likely were some, but their identification depended on the degree and extent of radicality of the paraaortic lymph node dissection, although all dissections were performed to the level of the left RV. Another reason may be due to the fact that a large percentage of renal arterial variations are in the so-called *Golden Triangle*. As discussed earlier, lymphatic dissection in this area is not desirable.

There was one case of aortic inferior polar RA – in the cadaveric dissection.

7.2.1. Discussion

Lesion of an accessory left RA may occur in paraaortic lymph node dissection in the infra- or supracolic regions. During dissection in the aortocaval and paracaval regions, the possibility of a lesion of an accessory right RA should be considered. The accessory aortic inferior polar or hilar RA are of greatest surgical importance among the accessory renal arteries. These two anomalous vessels also give an accessory branch to the cranial portion of the ureter. Iatrogenic injury to such an abnormal renal vessel may result in ureteral ischemia followed by necrosis, fistula, and urine leakage into the abdominal cavity. Ligation or laceration of the accessory aortic inferior polar RA may cause segmental ischemia and necrosis of at least 30% of the renal parenchyma. This is because such types of arteries are end-arteries, carrying the blood supply to the lower pole of the kidney. A similar case was reported by Eitan et al. The authors reported a lesion of the accessory inferior polar RA during paraaortic lymph node dissection of a patient with endometrial carcinoma. As a result of the lesion, an infarction of the lower pole of the kidney developed. Fortunately, the patient recovered and reported no further long-term complications that could have impaired her quality of life.

An anatomic classification of the accessory renal arteries was created.

7.3. Variations of the renal veins

7.3.1. Results

No such variations were found intraoperatively or during cadaveric dissections.

7.3.2. Discussion

Lesion of the left postcaval and circum-aortic RV is possible when performing paraaortic lymph node dissection in the aortocaval and infra- and supracaval areas. The presence of a precaval RV does not exclude the existence of a postcaval one. The presence of a postcaval RV may increase the volume of lymphatic dissection because gynaecologic oncologists cannot find the ventral border, the precaval RV. This can lead to a catastrophic injury of the superior mesenteric artery located immediately above the precaval RV.

7.4. Anomalies of the ureter

7.4.1. Results

Intraoperatively, 4 ureteral anomalies were found in 4 patients – 3 cases of double ureter (2 – right; 1 – left) and one case of true ureteral diverticulum localised on the right side (Figure 23). All four patients had no preoperative urological complaints and reported no similar complaints in the past. Retroiliac and retrocaval ureters were not detected intraoperatively or during cadaveric dissections.

7.4.2. Discussion

Ureteral anomalies can be divided into three groups:

A) Multiple ureters – the presence of two or more ureters unilaterally or the presence of two or more ureters bilaterally;

B) Ureteral diverticulum;

C) Retro-iliac ureter.

Anatomical variations of the ureters increase the risk of their damage. In pelvic lymph node dissection and radical hysterectomy, identification of the ureters should be the first step before starting the procedures. Blood supply to the double ureters should not be disrupted, as they are in common ligamentous connective tissue sheath rich in blood vessels. The double ureter can be confused with a vessel and ligated during surgical interventions. For this reason, gynaecologists should monitor peristalsis before ligating any vessel near the ureter. In some cases, the ureteral diverticula may mimic the presence of a retroperitoneal cyst. Therefore, the ureter should be identified and mobilised before any retroperitoneal dissection.

7.5. Anomalies of the iliac arteries

7.5.1. Results

There were 11 variations in the shape of the external iliac artery – 8 cases intraoperatively and 3 during cadaveric dissections. In 6 cases, the artery was S-shaped. In 4 cases, there were curvature variations of the iliac artery directed caudally, and in 1 – it had multiple curvatures (Figure 24).

Figure 24. Shape anomalies of the external iliac arteries. A, B – curvature directed caudally. C – S-shaped. EIA/EIV – external iliac artery/vein. IIA – hypogastric artery

7.5.2. Discussion

In theory, if the rules of dissection are followed, a lesion of the iliac arteries occurs relatively rarely since their wall is more elastic and dense (rich in collagen and elastin) than the venous wall. However, a lesion is possible if the iliac arteries have a different shape. This would greatly confuse gynaecologists if they are unfamiliar with the possible arterial variations of iliac vessels.

7.6. Anomalies of the iliac veins

7.6.1. Results

Intraoperatively, 2 iliac vein anomalies were identified – a double HV and a venous connection between the HV and the external iliac vein. No venous abnormalities were found during cadaveric dissections.

7.6.2. Discussion

The anomalies of the iliac veins are significantly more common and of greater surgical significance than those of the arterial veins. Surgeons should be alert for venous variations because their injury is more likely than in arterial ones. Bleeding from abnormal HV is extensive and challenging to control.

7.7. Anatomical variations of v. circumflexa iliaca profunda

7.7.1. Results

We encountered 10 cases of v. circumflexa iliaca profunda, localised below the external iliac artery (Figure 25).

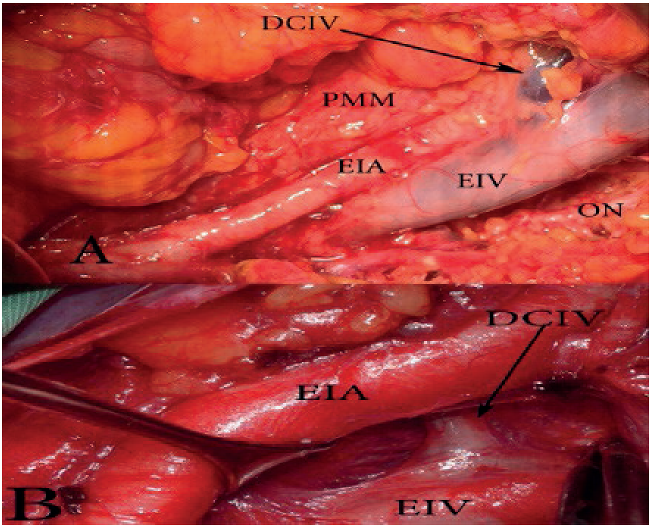

Figure 25. Normal anatomy (A) and variations (B) of v. circumflexa iliaca profunda (the vein passes under a. iliaca externa). EIA/EIV – arteria et vena iliaca externa; DCIV – v. circumflexa iliaca profunda; PMM – musculus psoas major; ON – nervus obturatorius

7.7.2. Discussion

In a large percentage of cases, the vein passes over the external iliac artery, but in 17.5% of the cases, it may be localised under the artery. Gynecologic oncologists should be aware of this variation because otherwise, they would expand the volume of pelvic lymph node dissection, which could lead to lymphedema or a lesion of the inferior epigastric artery.

IV. CONCLUSION

Retroperitoneum has always been a subject of intense interest by anatomists and surgeons. The more complex anatomy in the retroperitoneal space – a continuous network of blood vessels, nerves, ureters and some internal organs, makes gynaecologists avoid dissecting it. In recent years, with advances in surgical techniques and the advent of laparoscopy, dissection of the retroperitoneal space is an integral part of many gynaecologic procedures. The retroperitoneum is a subject of continuous research – new vascular-free spaces are being identified, and new methods in the surgery of deep pelvic endometriosis or correction of uterine or vaginal prolapse have been introduced. In order to perform a precise and confident dissection, the operator must be familiar with the detailed topographic anatomy in the retroperitoneum. Identifying the ureter and dissection of vascular-free spaces should be the initial step in performing many surgical procedures in this area. Anatomic variations in the retroperitoneum are not a small percentage. The operator should be familiar with their possible presence during dissection. Each patient should be treated as someone in whom anatomic variation may be found. Establishing classifications of anatomic variations which specifically address gynaecologic surgery can significantly reduce intraoperative complications. Gynaecologists must be able to manage every single complication arising from dissection in the retroperitoneal space, both intra- and postoperatively.

V. APPLICATIONS

1. Different approaches to the retroperitoneum can find application in any surgical intervention in the small pelvis, depending on the intraoperative status of the patient.
2. Dissection of different vascular-free areas is integral to any retroperitoneal pelvic procedure.
3. The new pelvic lymph nodes classification allows gynaecologic oncologists to assess the significance of the individual lymph node groups. Dividing paraaortic lymph node dissection into zones helps to facilitate surgical orientation during dissection.
4. Dividing the retroperitoneal zones of the ureter in detail highlights the sites with the highest risk of ureteral lesion during retroperitoneal dissection.
5. Detailed study of the anatomy of Corona mortis, aberrant, and accessory vessels reduces their intraoperative damage rate.
6. VIL and VLA variations can be lacerated during pelvic lymph node dissection.
7. There are numerous variations of the anatomical structures in the retroperitoneum, and gynaecologists should be familiar with most of them to avoid iatrogenic damage.

VI. CONTRIBUTIONS

Applied contributions

1. Many surgical approaches to the pelvic retroperitoneum in gynaecology have been studied.
2. All vascular-free spaces in the small pelvis have been analysed. New surgical borders for some of them have been defined.
3. The ureter is divided into 5 zones. The areas with the greatest risk of iatrogenic damage to the ureter were studied in detail.

Theoretical contributions

1. The groups of pelvic and paraaortic lymph nodes are defined. A new classification of pelvic lymph nodes from a surgical standpoint has been proposed. Paraaortic lymph node dissection is divided into zones.
2. VIL and VLA variations and their frequency have been described for the first time in gynaecologic surgery.
3. A classification of Corona mortis, aberrant and obturator vessels is proposed. The risk of damage to the mentioned vessels in gynaecologic oncology and urogynecologic surgery is described in detail.
4. Most anatomical structural anomalies in the retroperitoneum have been studied in detail. A classification of IVC, RA and iliac veins variations is presented.

VII. THESIS-RELATED PUBLICATIONS

1. **Kostov, S**., Slavchev, S., Dzhenkov, D., Stoyanov, G., Dimitrov, N., & Yordanov, A. D. (2021). Corona mortis, aberrant obturator vessels, accessory obturator vessels: clinical applications in gynaecology. Folia morphologica, 80(4), 776–785. https://doi.org/10.5603/FM.a2020.0110, ISSN: 1644-3284
2. **Kostov, S.,** Slavchev, S., Dzhenkov, D., Stoyanov, G., Dimitrov, N., & Yordanov, A. D. (2021). Median sacral artery anterior to the left common iliac vein: from anatomy to clinical applications. A report of two cases. Transl Res Anat 22:100101, https://doi.org/10.1016/j.tria.2020.100101, ISSN: 2214-854X
3. **Kostov, S**., Kornovski, Y., Slavchev, S., Ivanova Y., Dzhenkov, D., Dimitrov N., & Yordanov, A.D. (2021). Lateral Transperitoneal Accesses to the Pelvic Retroperitoneum in Gynecology: Surgical Technique, Anatomical Landmarks and Variations. Indian J Gynecol Oncolog 19, 64. https://doi.org/10.1007/s40944-021-00554-4, ISSN: 23638397
4. **Kostov S.,** Hinkova N., Dineva S., Yordanov A.. Embryological Aspects and Anatomical Variations of the Inferior Vena Cava – Its Importance in Gynecologic Oncology Surgery. Journal of Biomedical and Clinical Research. 2022;15(1): 30-40. https://doi.org/10.2478/jbcr-2022-0004, ISSN: 1313-9053

VIII. DECLARATION OF AUTHENTICITY

I hereby declare that this thesis and all data presented are original and obtained as a result of my research at St. Anna Hospital – Varna.

The results, discussions and conclusions are not written in any medium or sources except where appropriate references have been made.