Chapter

Robotically Assisted Hysterectomy

Petre Bratila, Anca Manta, Alexandra Paun and Elvira Bratila

Abstract

Starting from the first robotic hysterectomy, currently, this method is widely accepted all over the world as an alternative to open or laparoscopic surgery due to the technical advantages it offers. We are currently using the DaVinci Xi platform, whose components, instruments, and accessories are described. This chapter aims to present all surgical steps of a robotically assisted hysterectomy, starting with patient positioning, uterine manipulator insertion, port insertion, pneumoperitoneum performing, and the operative technique of the total robotic hysterectomy: connective vascular disconnection, colpotomy, uterus retrieval, and colporrhaphy. A special mention belongs to radical robotic hysterectomy with sentinel node detection and pelvic lymphadenectomy. The chapter ends with a brief description of the perioperative complications.

Keywords: robotics, hysterectomy, surgical technique, minimally-invasive, artificial intelligence, robotically assisted hysterectomy, Da Vinci Xi platform, surgical steps

1. Introduction

The idea of using robotic systems in surgery was proposed as early as 1967; it took more than 30 years of study and thorough research to complete the first fully multifunctional surgical robot. The first robotic System used was ROBODOC, used in orthopedic surgery for hip prosthesis; it was developed and used by Hap Paul and William Bargar in late 1980 [1–3]. Subsequently, systems were created and used in urology, prostate surgery, neurosurgery, otorhinolaryngology, gynecology, and cardiovascular surgery [4].

The United States Department of Defense developed the concept of robotic surgery to provide fast, high-precision surgical assistance directly on the battlefield. The prototype built contained two separate units: the surgeon's working unit and a remote-controlled surgical unit [5]. The System consisted of two video cameras that sent images from the operating field to a remote console. The surgeon could safely steer the robot's arms, thus accessing surgical instruments. This prototype has undergone several changes and improvements over time [6].

There are currently three types of robotic surgical systems: the AESOP, the Da Vinci System, and the ZEUS System. Currently, an essential multifunctional robotic surgery system approved by the FDA is the Da Vinci type from intuitive surgical Inc., which is used worldwide. The Da Vinci System comprises the surgeon's console, the video system, and the patient's cart, containing three or four robotic arms. The surgeon at the work console remotely directs the instruments attached to the robot arms [7].

In 1997, the first Da Vinci prototype was tested in humans, demonstrating the effectiveness of multiple joint instruments in abdominal and cardiovascular surgery. The FDA approved using this System in surgical practice in 2000 [8]. Since 2005, the Da Vinci System has been approved in the United States for use in gynecological procedures, both benign and malignant. The most highly-performed major surgical procedure in gynecology is a hysterectomy [9].

The first simple robotic hysterectomy was performed in 2002, and the first radical robotic hysterectomy was completed four years later, in 2006 [10]. The robotic hysterectomy is widely accepted as an alternative to open or laparoscopic surgery due to the technical advantages of robotic surgery, including 3-dimensional viewing, more precise control of instruments, and further articulation of tools, which enable surgeries to perform complex procedures more carefully. Minimally invasive robotic surgery is used today for up to 30% of benign and up to 65% of oncology cases in gynecologic surgery [11].

1.1 The robot: DaVinci Xi last generation

The DaVinci Xi platform is the 4th generation of the Da Vinci System.

The System has four components: surgeon console, patient cart, vision cart, and electrosurgery unit.

1.1.1 The Surgeon Console

The Surgeon Console provides an ergonomic design for the surgeon's comfort during surgery. It has a 3D Viewer, which enhances the vision of anatomy, and hand controls, which have intuitive motion translated into precise, delicate, tremor-filtered movements at instrument tips (**Figure 1**).

Figure 1.
A patient cart, trocars, and instruments.

1.1.2 The Patient Cart

This presents an adjustable support structure named boom which offers flexibility in positioning his arms over the surgical table. It has universal arms which allow the assignment and re-configuration of endoscope and instruments to desired ports during a surgical procedure.

The Helm touchpad allows non-sterile OR Staff to select the Patient Cart setting and adjust boon height or position for the best efficiency.

1.1.3 The Vision Cart

It is composed of a touchscreen monitor, an ERBE VIO dV generator, and an endoscope controller. The Endoscope controller provides a high-intensity light source to illuminate the surgical site and houses electronics that promote efficient endoscope setup.

The touchscreen monitor provides a high-quality view of the surgical image and allows non-sterile OR Staff to adjust vision settings and troubleshoot faults.

1.1.4 The electrosurgical unit

An ERBE VIO dV generator is integrated with the System; this electrosurgical unit (ESU) indicates the location of installed energy instruments and displays the energy effect setting at the surgeon console, increasing surgeon autonomy.

1.2 Instruments and accessories

1.2.1 The access instruments

- 8 mm cannulas, 5–8 mm cannula seals, 8 mm blunt obturator, 8 mm bladeless obturator and an 8 mm 0° or 30° endoscope

The endoscope allows magnified 3D High-Definition vision and provides a consistently clear view of the surgical field. The surgeon can adjust up or down 30° cameras according to the necessities. The camera can change vision in infrared.

1.2.2 Surgical instruments

- Monopolar curved scissors are protected by a neutral tip cover.

- Fenestrated bipolar forceps are used for grasping, retraction, dissection, and bipolar coagulation of the tissue.

- Maryland bipolar forceps are used for the same action as fenestrated bipolar forceps,

- Non-energy grasper (Cadiere grasper)

- Needle drivers
- Prograsp forceps

Special devices can be adapted to the arms of the robot as:

- *Synchro Seal* enables to seal and cut of vessels up to 5 mm in diameter and tissue bundles that fit in the jaws. The average sealing time is less than 2 s.
- *Vessel Sealer Extend* securely seals and cut vessels up to 7 mm in diameter or tissue bundles that fit in the jaws. The sealing time is less than 3 s. It presents four functions: grasp, dissect, seal, and cut.
- *Ultracision* seal and cut tissues using ultrasounds, best used for robotic myomectomy (**Figures 2–10**).

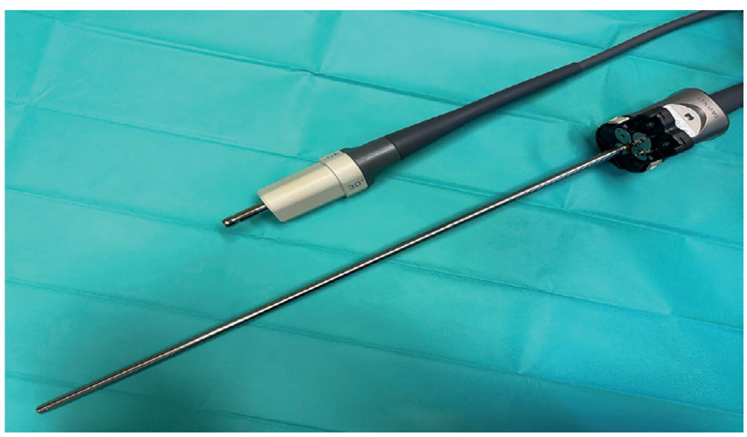

Figure 2.
3D camera.

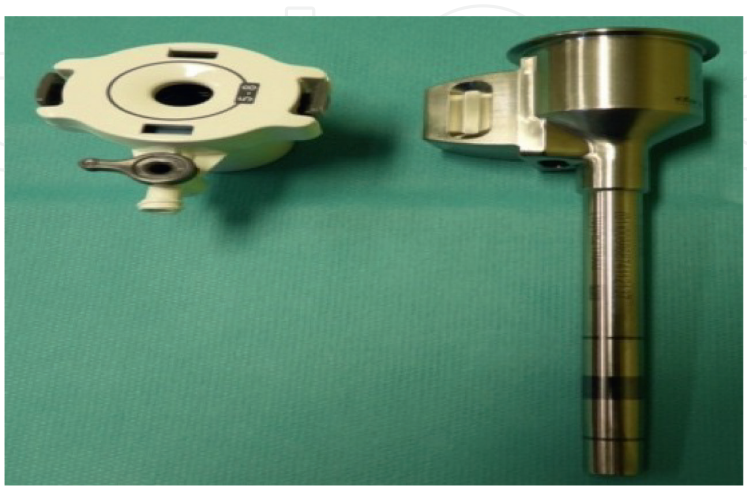

Figure 3.
Canula and canula seals.

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Figure 4.
Cannulas with a bladeless and blunt obturator.

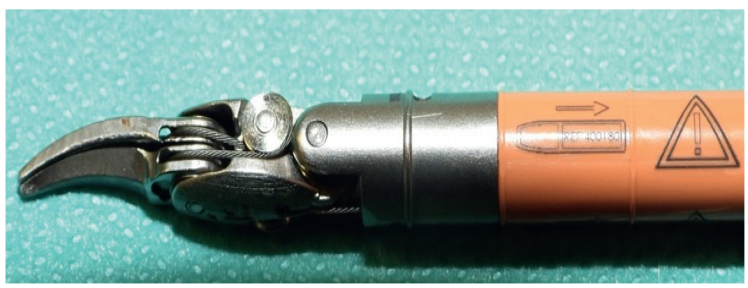

Figure 5.
Monopolar curved scissors.

Figure 6.
Bipolar fenestrated forceps.

Figure 7.
Maryland bipolar forceps.

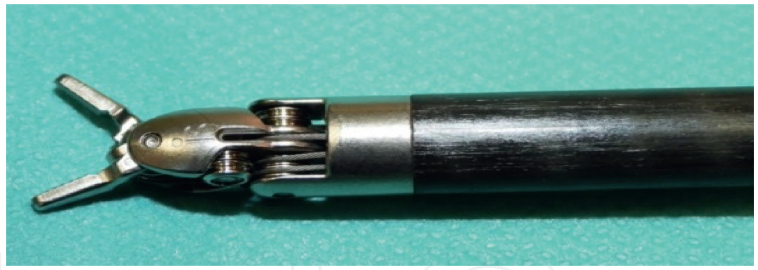

Figure 8.
Large needle driver.

Figure 9.
SynchroSeal @Intuitive Corporation Sunnyvale, CA, USA (Sofmedica, Romania).

Figure 10.
Vessel Sealer Extend @Intuitive Corporation Sunnyvale, CA, USA (Sofmedica, Romania).

2. Operation theater setup and operative access

2.1 Patient positioning and the uterine manipulator insertion

The uterine manipulator allows to move the uterus up and down or in a lateral position. To facilitate the insertion of a uterine manipulator, the patient must be placed in a lithotomy position with legs in stirrups and spread apart in slight ventral flexion. The buttocks must be placed slightly over the edge of the operating table, a position that allows movements of the uterine manipulator.

A bladder catheter is inserted before the uterine manipulator placement.

The patient arms must be placed along the body to avoid injury to the brachial plexus.

We use the Koh manipulator with three different cups according to the dimensions of the cervix and vagina. For robotic surgery, we need a prominent Trendelenburg position (25–30°). The shoulder braces are mandatory to avoid slipping.

2.2 Abdominal access. First port insertion. Pneumoperitoneum

In most cases, the access for the vision port is done transumbilical. The umbilical area is the thinnest abdominal wall area, where aponeurosis detaches difficult from the peritoneum.

We anchor the umbilicus with two forceps, and a small incision of the skin is made to allow the insertion of the Veress needle. The correct positioning of the Veress needle inside the peritoneum is checked using known tests: suction, drop, or pressure tests. For abdominal placement of the vision port, the surgical table must be placed in a neutral position to avoid the risk of vascular injury of great vessels.

The pneumoperitoneum, for gynecological surgeries, is done to a pressure of 12–15 mmHg. To allow the insertion of an 8 mm trochar, the umbilical incision will be extended. The trochar is inserted perpendicular to the abdominal wall with the shutter mounted. When removed the shutter, a gas jet under pressure is heard, a sign that the instrument is correctly placed. Connect the cannula tap to the CO2 insufflation system and insert the camera [11, 12].

Other methods of making pneumoperitoneum, the Henson trochar approach, the visiport trochar, or the Veress optical needle, are rarely used [12].

2.3 Ancillary trochars placement

The working trochars are inserted under visual control. The incision in the skin will be about 8 mm to allow the tight insertion of the trocar. We use, for gynecological surgery, 3 or 4 Da Vinci trochars and one assistant's trochar placed in line. In the case of a simple robotic hysterectomy, we put four trochars in the umbilical cord. The distance between the trochars should be about 8–10 cm to avoid crossing the instruments during surgery. For fragile patients, the holes can be placed at distances of up to 4 cm without exceeding this value. The Da Vinci system trochars, marked with three black lines, are inserted so that the midline is placed at the level of the peritoneum.

The assistant surgeon uses a 12 mm trochar to couple the Air Seal system. It is placed on the right or left side, either on the umbilical line or triangular and cranial, between the optical and Da Vinci 2 or 3 ports.

The distance between the assistant and Da Vinci ports must exceed 7 cm.

Place the patient in the Trendelenburg position at 25‾30°. In the case of the adjoining syndrome, under visual control, adhesiolysis is performed. Remove the small intestine and epiploon from the visual field with an atraumatic pen. Place the surgical table in the lowest position possible. Dock arm 2 of the Da Vinci System at the endoscopic port. Insert the 8 mm 30 degrees endoscope and target the pubic symphysis. Arms 2 and 3 are docked.

The work tools are inserted as follows: on arm 2, the bipolar or vessel sealer extends is mounted, and on arm three is mounted monopolar curved scissors. Arm 4 will remain stowed (**Figure 11**).

3. The robotic hysterectomy

Hysterectomy is one of the most common non-pregnancy-related gynecological surgeries. There are three main types of hysterectomy [13]: *Total hysterectomy, Supracervical* hysterectomy, and *Radical hysterectomy.* The uni- or bilateral adnexectomy or salpingectomy can be associated with any type of hysterectomy.

Figure 11.
Ancilliary trochars placement for Xi platform.

- *Total robotic hysterectomy* can be indicated for benign disease of the uterus or the early stages of endometrial cancer.

The specific indications for robotic assistance are:

- Morbid obesity
- Big uterus
- Previous complicated surgeries
- Deep infiltrating endometriosis
- Patient preference

For benign and malignant conditions robotic hysterectomy is equivalent to a type A hysterectomy in the Querleu Morrow classification. It represents an extra fascial hysterectomy in which all the uterine pedicles are resected as close to the uterus as possible. The area of the cut of the vagina is <10 mm. Ureterolysis is not necessary, but ureters must only be identified. The main advantage of this type of hysterectomy consists of the possibilities of uterus extraction in a natural way, through the vagina.

- *Supracervical hysterectomy*- involves the removal only of the uterine body. The cervix is preserved. The main indication for supracervical hysterectomy is the express desire of the patient to keep the cervix for benign uterine conditions such as dysfunctional bleeding resistant to treatment, uterine leiomyomatosis, and uterine adenomyosis. Supravaginal hysterectomy can be performed in cases when technically the cervix cannot be extracted. After a supravaginal hysterectomy, the uterine body cannot be extracted vaginally. The alternatives are in-bag morcellation and morcellation by mini-laparotomy.

- *Radical hysterectomy* remains the standard surgical treatment for the different early types of cervical cancer and endometrial cancer. If for early cervical cancer, the lymphadenectomy is mandatory for endometrial cancer stage, I or II it must respect the molecular classification and degree of risk. The real radical hysterectomy is represented by Types B and C from Querleu Morrow's classification.

Current guidelines from NCCN and ESGO indicated that both open surgery and minimally invasive surgery performed by conventional (laparoscopy) or robotic techniques are acceptable approaches to radical hysterectomy with pelvic lymphadenectomy in patients with early-stage cervical cancer and endometrial cancer [14–17]. The retrospective study showed that robot-assisted radical hysterectomy was associated with better perioperative outcomes than the open approach, and the recurrence rates and survival rates do not differ significantly between these two ways of performing radical hysterectomies [14, 17].

3.1 Total robotic hysterectomy-operative technique

The robotic hysterectomy starts with an abdominal cavity inspection. Once the pneumoperitoneum was created, we checked the trochar's placement and the presence of possible intestinal or vascular trochar insertion injuries.

All four quadrants of the abdominal cavity must be inspected, including the liver and diaphragm.

The whole pelvis will be exposed after we mobilize the small bowel and sigmoid and perform adhesiolysis if it is necessary. Uterine and adnexa inspection aim to check the adequate uterine manipulator insertion and anatomy of the adnexa, the position of ureters, and the vascular axes of the pelvis.

The technique of total hysterectomy requires *disconnecting of the uterus* and cervix from vascular and connective elements of the supporting System, *section of the vagina*, *extraction* of the uterus, and *closing of* the vaginal cuff.

3.2 Connective vascular disconnection

The uterus is kept in anatomical position at three levels of connective vascular pedicles: *the superior pedicle* consisting of round ligaments and utero-adnexal or infundibulopelvic ligaments, the *medium vascular pedicle* represented by leading uterine vessels and the *inferior pedicle* consisting of cervicovaginal vessels. Only the superior pedicle is intraperitoneal, the medium and inferior being between the two folds of large ligaments. The disconnection will be done by both sides of the uterus.

3.2.1 Superior pedicle disconnection

- Starts with coagulation and sectioning of *the round ligament* at the level of the avascular triangle of the broad ligament. The triangle is limited by adnexal vessels medially, extern iliac vessels laterally, and round ligament caudally (**Figure 12**).

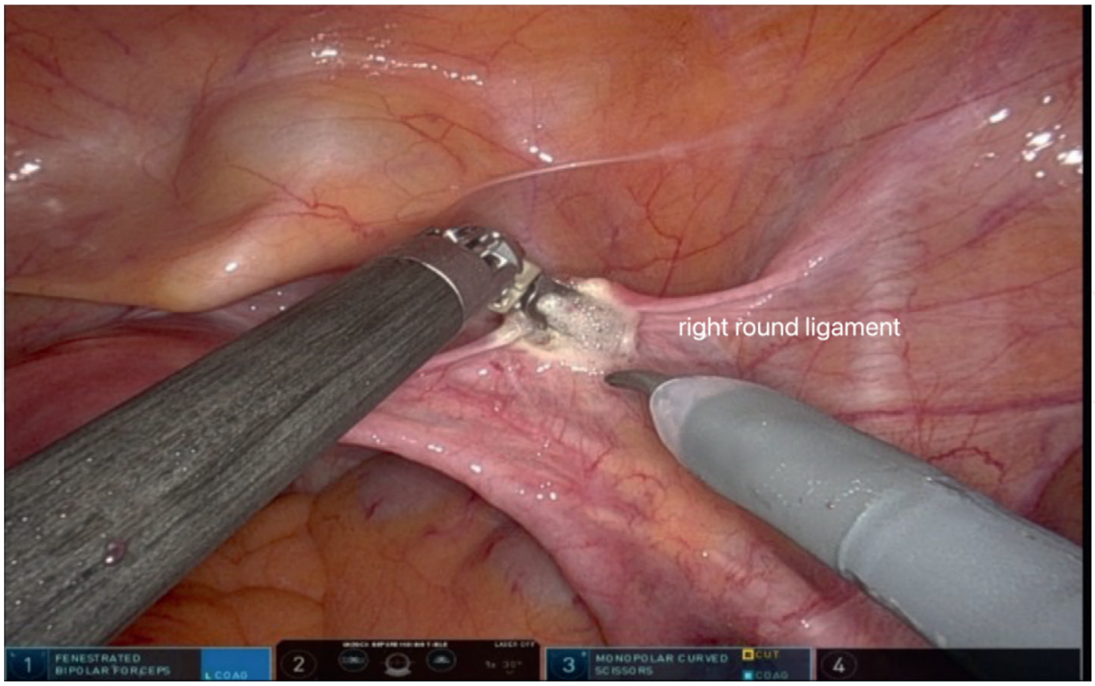

Figure 12.
Coagulation and section of the right round ligament.

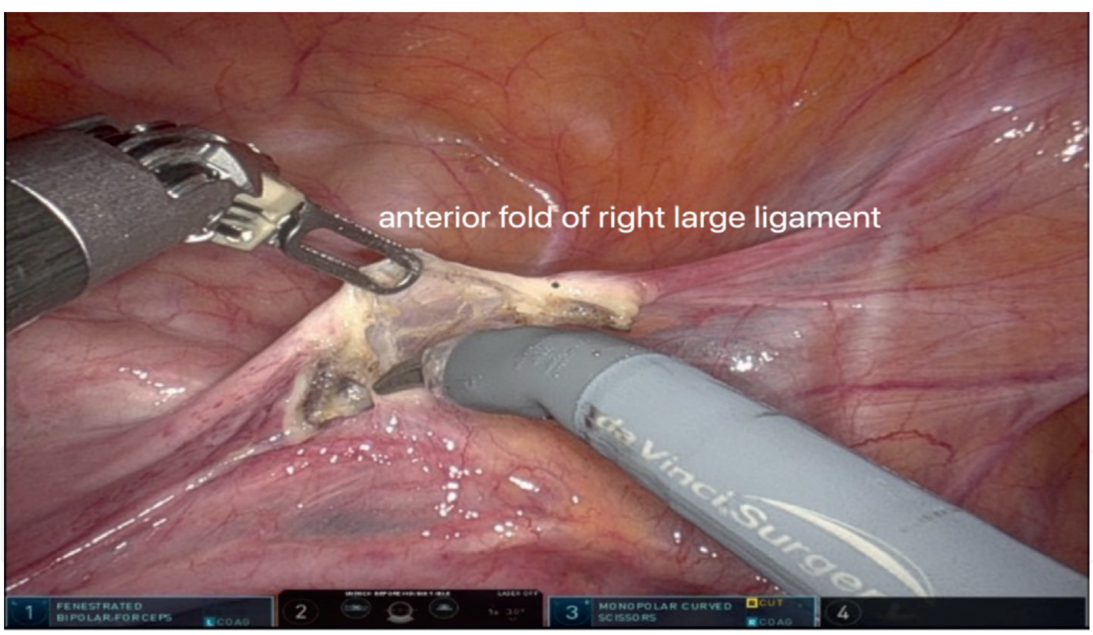

Figure 13.
Sectioning of the anterior fold of broad ligament.

- Division of *anterior and posterior fold of the broad ligament* and entrance in the retroperitoneal space. Sectioning of the anterior fold of the broad ligament, by dissection and coagulation towards the medial vesical line (**Figure 13**).

- Coagulation and section of *utero-ovarian or infundibulopelvic ligaments* (left and right). We recommend at first performing fenestration of the broad ligament at

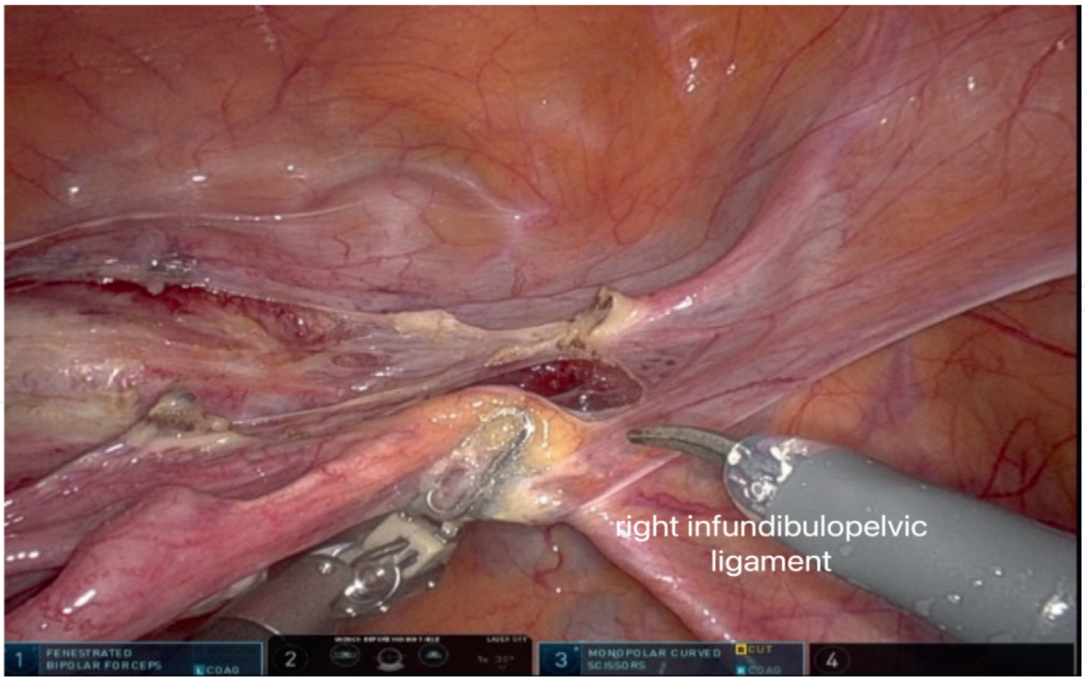

Figure 14.
Coagulating and division of the infundibulopelvic ligament.

the level of the gray triangle. This maneuver allows to check the position of the ureter in the dissection area (**Figure 14**).

- *Utero-ovarian pedicle* disconnection will be done by separate coagulation and sectioning of the fallopian tube and utero-ovarian ligament. An important vascular anastomosis between the two elements links the fundal uterine artery and veins to the tubo-ovarian arcade. The level of the section must be in the gray triangle away from uterine insertion.

- *Infundibulopelvic disconnection* is an important step concerning the risk of ureteral injury. Before coagulating the ligament, it must be skeletonized by a section of the peritoneum in the direction of external iliac vessels. The ureter is just under the pedicle. The coagulation will be done step by step in the direction of the fenestrated large ligament.

3.2.2 Dissection of the vesicouterine space

Sectioning the anterior fold of the broad ligament allows for dissecting the vesicouterine space. The junction of the peritoneum between the bladder and uterus looks like a white line. The incision of the peritoneum must be performed caudal to this line (**Figures 15** and **16**).

In the case of previous cesarean sections, this limit is hard to see, and entering into the cervico-vesical space is difficult. Dissection will be made step by step searching the contact with the manipulator cup. After entering the vesico-cervico-vaginal space the limit between the bladder and vagina is cervicovaginal fascia visible as a white connective structure. The assistant grasps the bladder at the midline by anterior and superior traction and dissection is carried out in the midline. Laterally the bladder pillars must be coagulated and cut bilaterally.

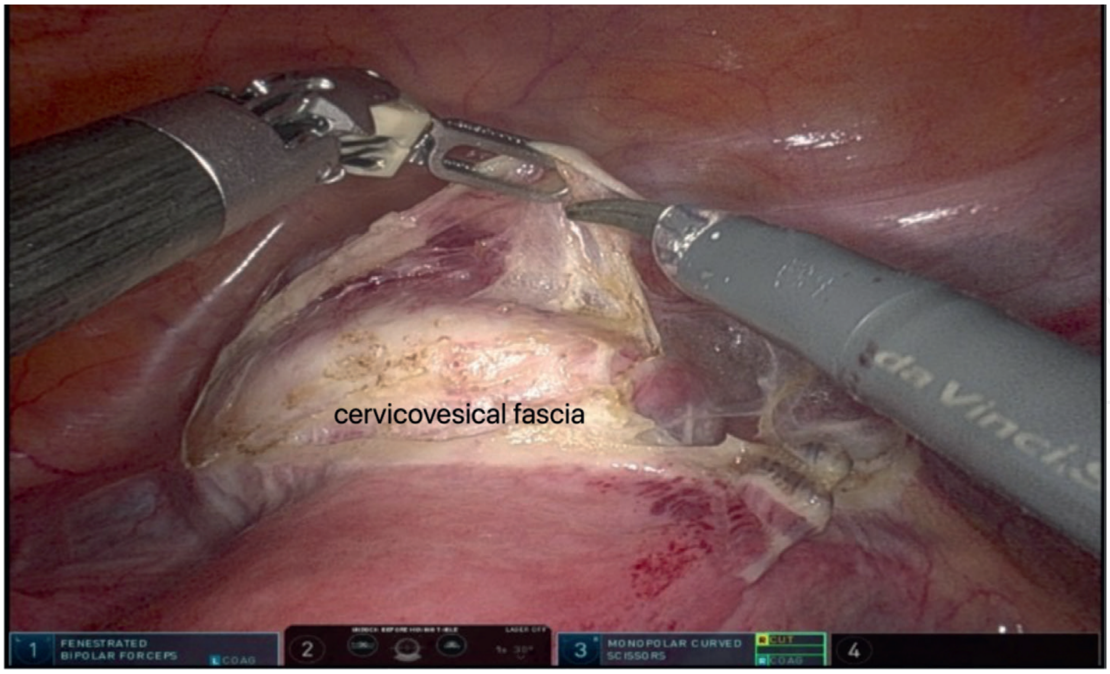

Figure 15.
Dissection of vesicouterine space.

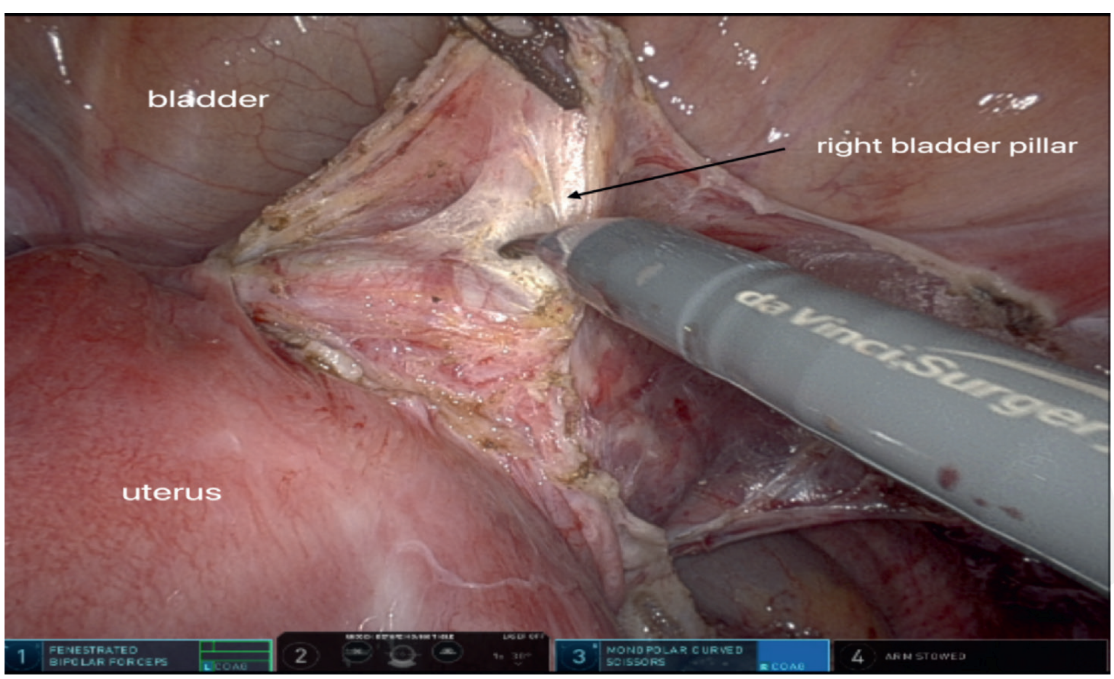

Figure 16.
Right bladder pillar.

3.2.3 Disconnection of the leading vascular pedicle

The first step to disconnect the leading vascular pedicle is to skeletonize the uterine vascular axes. It should be remembered that the division of the uterine artery is done at the level of the uterine isthmus. Here the main trunk is divided into an ascending and a descending branch. In this operative step, only the ascendant branch of the uterine artery is coagulated and sectioned.

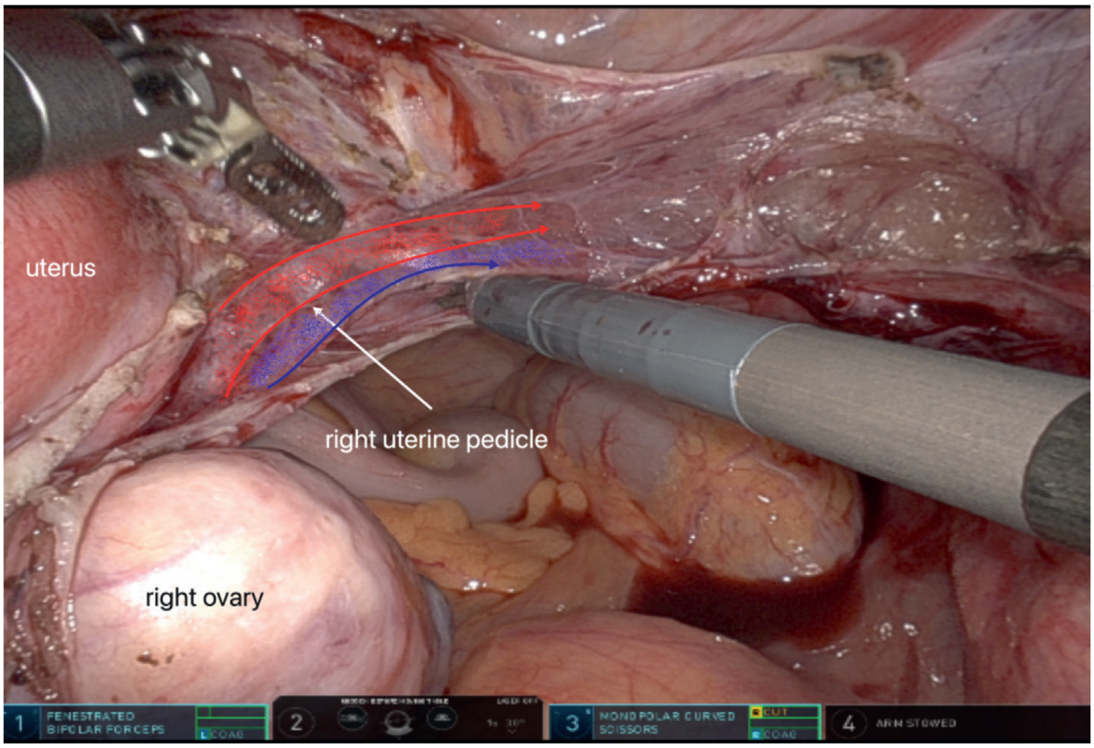

Figure 17.
Scheletonize the right uterine pedicle artery and vein.

To highlight the uterine vascular axis the posterior broad ligament peritoneum must be sectioned towards the uterosacral ligaments. In the vascular pedicle, the artery is located before the veins and the bleeding is easy to control. If the artery has a diameter of more than 5 mm a haemoclip is useful to control arterial bleeding (**Figure 17**).

3.2.4 Disconnecting the inferior connective vascular pedicle

The inferior connective vascular pedicle contains *a vascular part* represented by a descending branch of the uterine artery, cervicovaginal vessels, vaginal artery and veins, and the *fibrous supporting System* of the uterus that contains the cardinal uterosacral complex (CUSC).

For the ascendant branch of the uterine artery hemostasis is done with the bipolar clamp placed perpendicular to the axis of the uterus. For cervicovaginal vessels, coagulation and sectioning of are done parallel to the uterine axis. Usually, we do not coagulate and section the uterosacral ligaments separately. In some cases, with a big uterus, the coagulation and section of the uterosacral ligaments can help mobilize the uterus and facilitate the colpotomy (**Figure 18**).

3.3 Colpotomy

The colpotomy is an important step of robotic hysterectomy because if done correctly it prevents several complications to neighboring organs: ureteral, bladder, and rectum. To prevent these complications some rules must be followed:

- Do not dissect too much lower the inferior pedicle. The ureter is inside the bladder pillar.

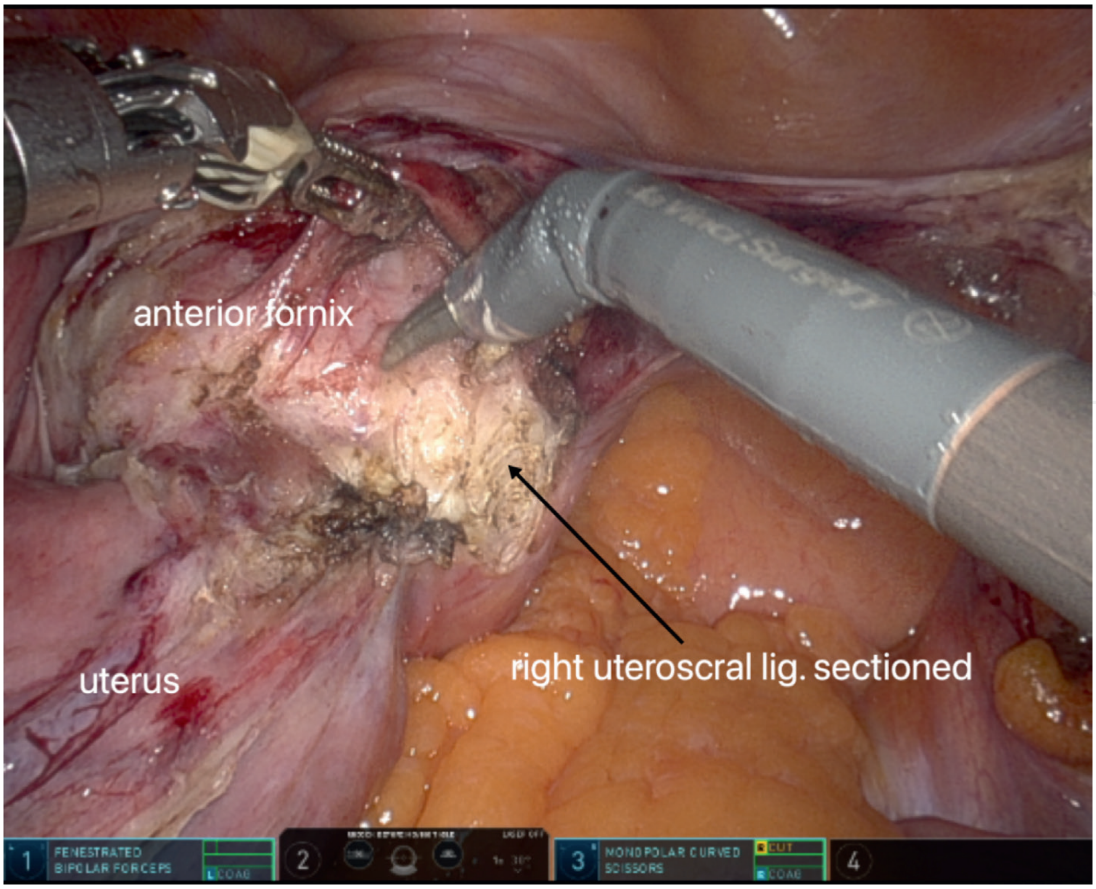

Figure 18.
Inferior pedicle. Cervicovaginal vessels are coagulated and sectioned. Right uterosacral ligament exposed and divided.

- If the CUSC is strong start the colpotomy posteriorly sectioning it.
- Completely frees the vaginal fornices.
- Be careful with adhesions to the torus of the uterus.
- Do not use excessive bipolar current to control hemostasis.
- Circumferential colpotomy starting at the lateral sides performed by monopolar scissors (**Figure 19**).

3.4 Extraction (uterus retrieval)

In most cases with big uteri, the time-consuming retrieval exceeds the time for uterus disconnection. In cases of a uterus weighing under 280gr vaginal retrieval is not a problem.

For the big uteri we can use other alternatives:

- Transvaginal morcelation
- In bag morcelation

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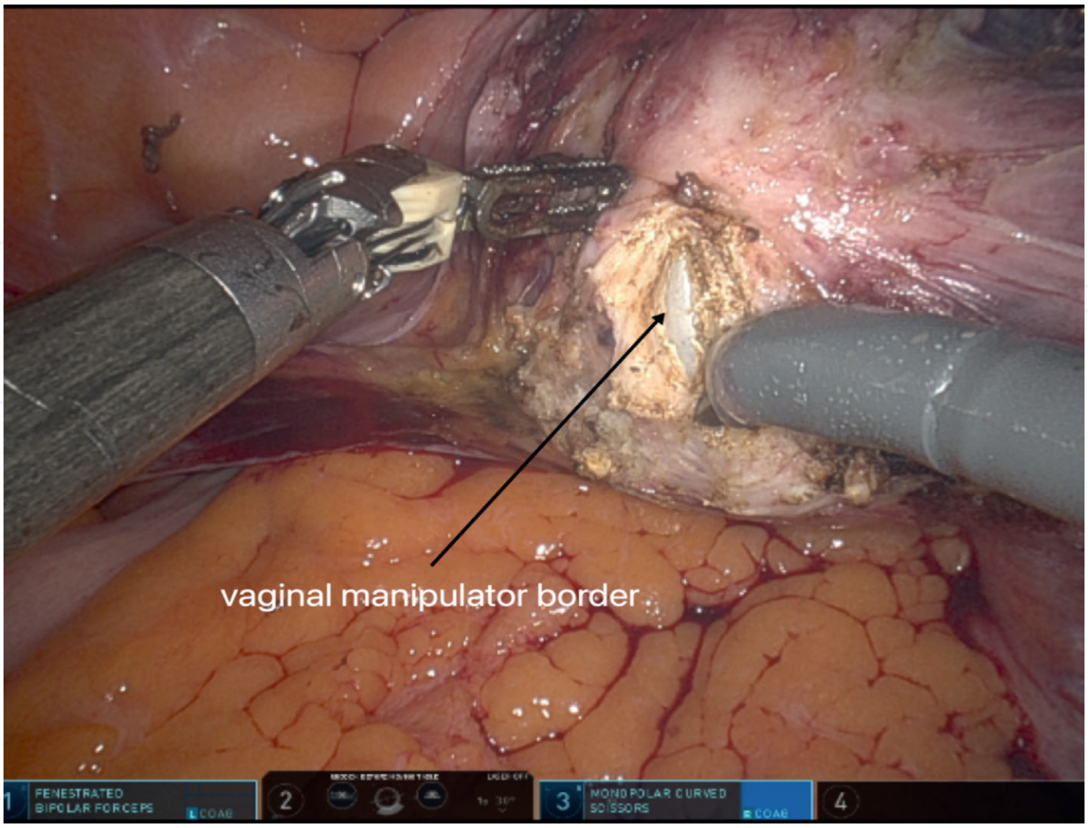

Figure 19.
Colpotomy starts from the lateral side of the vaginal cuff.

- Power morcelation
- Cutting morcelation (Chardoney)
- Minilaparotomy and morcelation

Transvaginal morcellation is the leading method for uterus extraction. For the surgeon trained in vaginal surgery extraction of a uterus weighing 500–1000 gr is not a problem. To extract the uterus transvaginally, we use some techniques:

- Hemisection (bivalve)
- Intramiometrial corring (Lash technique)
- Wedge morcellation
- A combination of these techniques

After colpotomy, the entire uterus remains free into the pelvis if the manipulator is extracted. The vaginal assistant grasps the cervix with a tenaculum pulling it into the vaginal canal.

Usually, we start transvaginal morcellation bilvalving of the uterus beginning from the external cervical orifice. This maneuver allows access to the lateral sides of the uterine body allowing to start the intramiometrial corring. The uterine body tissue is cut circularly with a knife or scissors forming a cylinder of tissue to reduce the volume of the uterus. If necessary, tissue fragments can be cut for uterine reduction. Finally, the whole uterus will be extracted vaginally.

3.5 Colporraphy

Closing the vagina is the final step of hysterectomy. We close the vagina by continuous uninterrupted sutures in one layer, including enough width of the vaginal mucosa, fascia, and uterosacral ligaments to strengthen pelvic support. We use resorbable suture (Vycril no. 1) or barbed suture No.00 (**Figure 20**).

3.6 Final step

Hemostasis and final inspection and pelvis irrigation and aspiration. We check vascular pedicles, vaginal vaults, ureters, and bladder. We check the presence of unapparent injuries in surrounding structures. We lower intra-abdominal pressure to 9 mmHg to see the hemostasis efficiency. We practice routine pelvic drainage for 24 h to prevent postoperative bleeding.

Undocking the platform is the next step. The trochars are removed under direct vision and we check parietal hemostasis. The pneumoperitoneum is exusuflated.

We close the fascia of the umbilical and assistant port. The skin incisions are closed with a subcuticular suture.

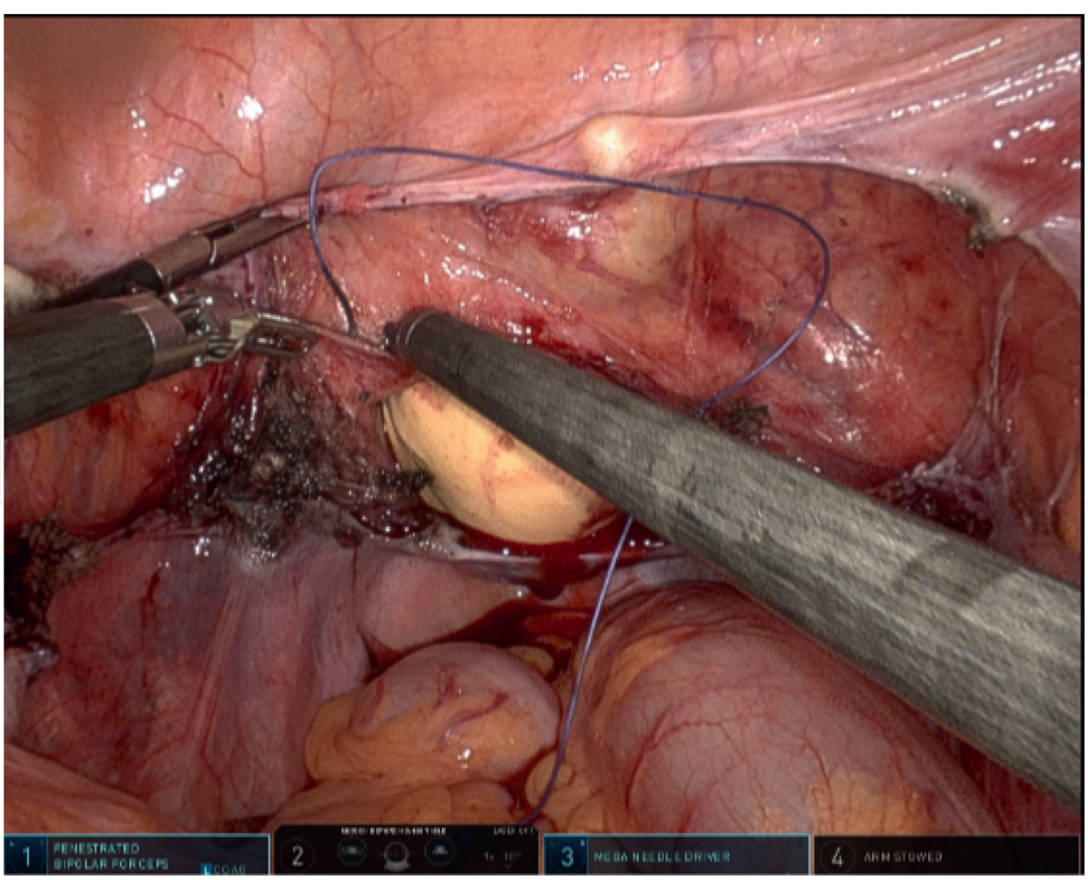

Figure 20.
Closing the vagina in one layer with running uninterrupted suture.

3.6.1 Radical robotic hysterectomy

Radical hysterectomy with pelvic lymphadenectomy with or without adnexectomy remains the standard recommended surgical treatment for the different types of gynecological cancer. Depending on the type of cancer (cervical, endometrial, or ovarian), one of the types of radical hysterectomy from the Querleu classification and pelvic lymphadenectomy is performed [13, 14, 18].

Radical robotic hysterectomy is indicated for the early stages of cervical and endometrial cancer. In most cases, the procedure can be associated with pelvic or paraortic lymphadenectomy. If for cervical invasive cancer, the lymphadenectomy is mandatory for endometrial cancer lymphadenectomy aims at surgical staging.

The first part of the procedure is like all types of hysterectomies. It involves the disconnection of the superior connective vascular pedicle and the dissection of the bladder from the cervix and vagina [19]. For all the procedures the vascular pedicle sealing is performed using electrosurgical instruments: bipolar clamp, ultrasound clamp, Vessel Sealer Extend, or SynchroSeal.

Surgical staging with pelvic lymphadenectomy with or without para-aortic lymphadenectomy defines recurrence risk and determines the clinician's decision to give patients adjuvant treatment (radiation or chemotherapy) [15]. Systematic surgical staging significantly reduces the necessity of external radiation, avoiding the complications of complete pelvic lymphadenectomy [20–23].

The concept of the sentinel lymph node (SLN) has been proposed as a less invasive solution for nodal assessment. The state of the sentinel node ganglion reflects the status of the entire nodal basin of pelvic lymph nodes [24–26] (**Figure 21**).

The leading step of radical hysterectomy is the dissection of parametria. The extension of parametrial resection is decided according to the clinical stage of the tumor. For stage IB of the cervix and stage II for endometrial cancer is recommended parametrial resection C2 and pelvic lymphadenectomy. For stage I endometrial cancer SLN detection and B2 are recommended (**Figures 22** and **23**).

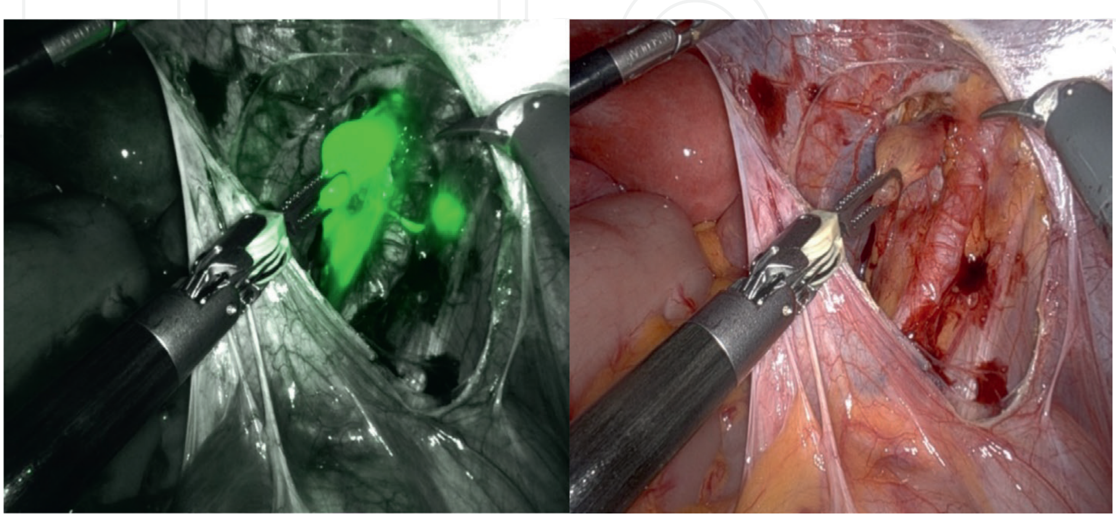

Figure 21.
SLN detection in obturator right fossa after 20 min after ICG intrastromal cervical injection.

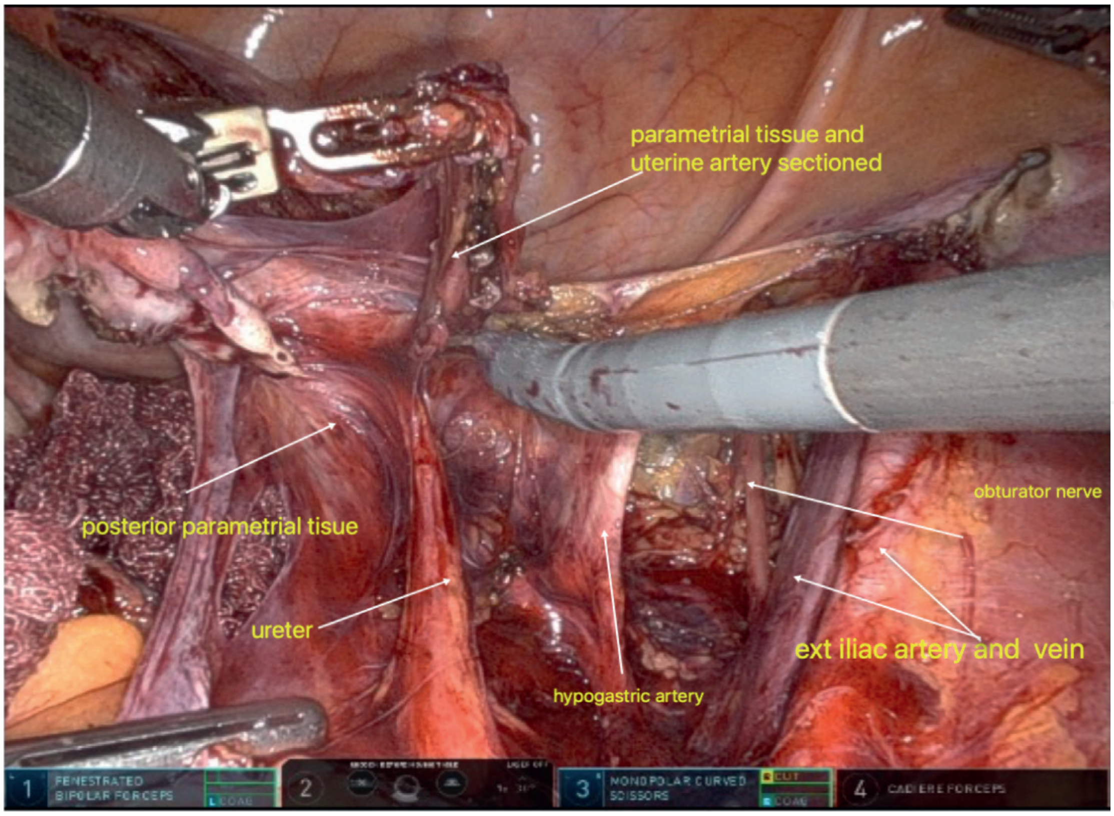

Figure 22.
Right side parametrectomy. The parametrial tissue is lifting to allow unroofing of the ureter.

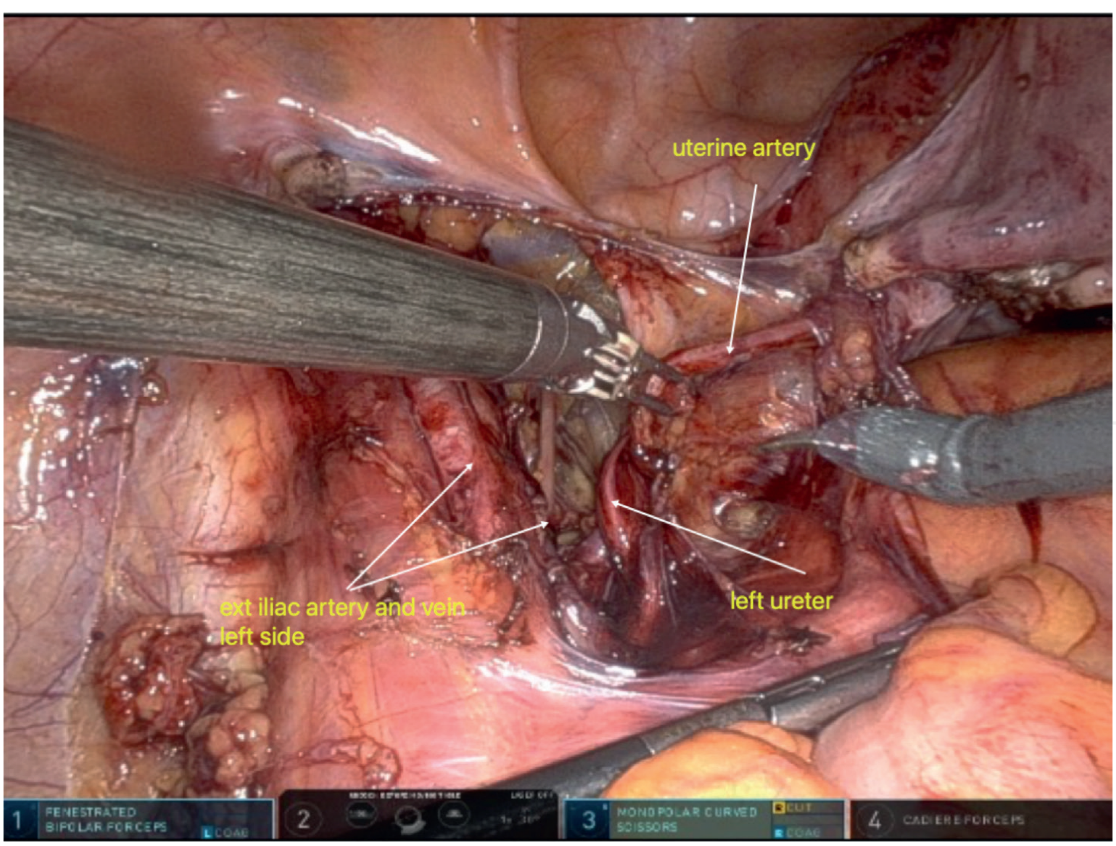

Figure 23.
Left side parametrectomy. Opening the Lazko space. The uterine artery can be seen crossing the left ureter.

4. Perioperative complications of robotic hysterectomy

Possible postoperative complications include fever, respiratory failure and pneumonia, postoperative ileus, sepsis, transfusion need, urine retention, and parietal complications [27–31].

Fever is the most common secondary complication of hysterectomy. The most common causes are urinary or respiratory tract infections. Most of the time, however, the etiology of fever is unclear; in patients with robotic interventions, it is not associated with increased sepsis, wound infections, or pneumonia. One possible explanation would be that it appears secondary to the atelectasis related to the increased duration of the Trendelenburg position [32].

The leading risk factor for *respiratory complications*, is the generally longer operating times in steep Trendelenburg position in robotic-operated patients [33].

The factors related to *urinary retention* in robotic hysterectomy patients remain unknown [28]. The solution is maintaining an indwelling urinary catheter for at least one day after a hysterectomy, especially in elderly patients.

Intraoperative complications are classified into hemorrhagic, digestive, and urinary tract complications. The occurrence of any of these complications can cause laparoscopic or laparotomic conversion. Most complications occur when inserting the first trocar. The most severe complication is bleeding from damage to large vessels [34, 35].

Intraoperative *hemorrhagic complications* in robotic interventions are rare, with a reduced need for transfusions compared to other types of hysterectomies [27].

Bladder injuries can occur during bladder-uterine dissection, being favored by a history of cesarean section. In particular, this type of injury is more common in radical interventions than in standard total hysterectomies because radical hysterectomy involves extensive dissection of periureteral tissue, unroofing of the ureteral tunnel, and the mobilization of the blender, It is essential to recognize them intraoperative. The incidence of bladder injuries during radical hysterectomy is between 0.4 and 3.7%.

Ureteral lesions depend on the complexity of the intervention, with a variable incidence between 0.08 and 4.2%. Most commonly, they occur through thermal injury or radical hysterectomy. The appearance of uterovaginal fistulas follows their non-recognition. The incidence of vesicovaginal and uterovaginal fistulas is between 0.9 and 2.0% [35–37].

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