Chirurgia (2023) 118: 187-201
No. 2, March - April
Copyright© Celsius
http://dx.doi.org/10.21614/chirurgia.2827

Surgical and Anatomical Basics of Pelvic Debulking Surgery for Advanced Ovarian Cancer – the "Hudson Procedure" as a Cornerstone of Complete Cytoreduction

Stoyan Kostov[1], Yavor Kornovski[1], Rafał Watrowski[2,3], Stanislav Slavchev[1], Yonka Ivanova[1] and Angel Yordanov[4]*

[1]Department of Gynecology, Saint Anna University Hospital, Prof. Dr. Paraskev Stoyanov Medical University, Varna, Bulgaria
[2]Department of Obstetrics and Gynecology, Helios Hospital Müllheim, Teaching Hospital of the University of Freiburg, 79379 Müllheim, Germany
[3]Faculty of Medicine, Medical Center–University of Freiburg, 79106 Freiburg, Germany
[4]Department of Gynecologic Oncology, Medical University Pleven, Pleven, Bulgaria

*Corresponding author:
Angel Danchev Yordanov, M.D.
bul Georgi Kochev 8A, Pleven
Bulgaria
Tel: +359887671520
E-mail: angel.jordanov@gmail.com

Abbreviations:
OC: ovarian cancer;
EnBRP: en-bloc resection of the pelvis;
TROMP: en-bloc resection of multivisceral-peritoneal packet;
LPP: lateral parietal peritoneum;
Ur: ureter;
LPS: lateral paravesical space;
MPS: medial paravesical space;
LS: Latzko space;
OS: Okabayashi space;
CL: cardinal ligament;
IIA: internal iliac artery;
UA: umbilical artery;
ON: obturator nerve;
SUL: sacrouterine ligament;
PMM: psoas major muscle;
Ut: uterus;
EIA: external iliac artery;
EIV: external iliac vein;
BL: bladder;
UtA- uterine artery;

Received: 03.02.2023
Accepted: 05.04.2023

Rezumat

Bazele chirurgicale și anatomice ale chirurgiei de debulking pelvin pentru cancerul ovarian avansat - „Procedura Hudson" ca piatră de temelie a citoreducției complete

Cancerul ovarian (CO) este a cincea cea mai frecventă cauză de deces la femei şi produce mai multe decese decât orice alt cancer al tractului reproducător feminin. CO se răspândeşte, de obicei, prin diseminare peritoneală şi invazie directă. Citoreducția optimă (fără boală reziduală macroscopică) şi chimioterapia adjuvantă pe bază de platină sunt fundamentele tratamentului CO. CO este, de obicei, diagnosticat în stadii avansate. Prin urmare, invazia fundului de sac Douglas de către tumoră, precum şi carcinomatoza peritoneală pelviană diseminată sunt frecvent observate. Citoreducția chirurgicală radicală necesită, de obicei, o abordare retroperitoneală a maselor tumorale pelviene şi rezecții multiviscerale în abdomenul superior. În 1968, Christopher Hudson a introdus o nouă tehnică chirurgicală retroperitoneală („oofo-rectomie radicală") pentru tumorile ovariene fixe. De atunci, au fost descrise numeroase modificări, inclusiv peritonectomia viscerală, tehnica „cocon", peritonectomia totală în bloc în formă de liliac (abord Sarta-Bat) sau rezecția en-bloc a pelvisului. Deşi aceste modificări au extins descrierea clasică în numeroase moduri, conceptele şi etapele chirurgicale cheie sunt derivate din procedura Hudson. Cu toate acestea, există unele lacune sau dezacorduri cu privire la raționea anatomică sau practică pentru

MR: mesorectum;
PS: presacral space;
IFA: inter-fascial approach;
TMRA: trans-mesorectal approach;
PMM: psoas major muscle;
MSA: median sacral artery;
R: rectum;
Pr: promontory;
SRA: superior rectal artery;
LIIA: left internal iliac artery;
LCIV: left common iliac vein;
RCIA: right common iliac artery;
LCIA: left common iliac artery;
LEIV: left external iliac vein;
AP: anterior peritoneum;
OTu: ovarian tumor;
SP: symphysis pubis;
LP: lateral peritoneum;
AVW: anterior vaginal wall;
PVW: posterior vaginal wall;
RVS: rectovaginal space;
RSH: rectal shaving of the anterior abdominal wall;
SG: sigma;
MSC: mesocolon;
RS: rectosigmoid colon.

anumite etape chirurgicale. Scopul acestui articol este de a sublinia etapele critice ale citoreducției pelvine radicale („procedura Hudson") şi de a stabili care este baza anatomică a procedurii în forma propusă. În plus, discutăm controversele şi abordăm morbiditatea perioperatorie asociată procedurii.

Cuvinte cheie: cancer ovarian, procedura Hudson, baza anatomică, morbiditate perioperatorie

Abstract

Ovarian cancer (OC) is the fifth most common cause of death in women and accounts for more deaths than any other cancer of the female reproductive tract. OC usually spreads through peritoneal dissemination and direct invasion. Optimal cytoreduction (no macroscopic residual disease) and adjuvant platinum-based chemotherapy are the fundaments of OC treatment. OC is usually diagnosed at advanced stages, hence the obliteration of the Douglas pouch by the tumor as well as disseminated pelvic peritoneal carcinomatosis are commonly seen. Radical surgical cytoreduction typically requires a retroperitoneal approach to the pelvic masses and multivisceral resections in the upper abdomen. In 1968, Christopher Hudson introduced a new retroperitoneal surgical technique ("radical oophorectomy") for fixed ovarian tumors. Since then, numerous modifications have been described, including visceral peritonectomy, the "cocoon" technique, Bat-shaped en-bloc total peritonectomy (Sarta-Bat approach), or en-bloc resection of the pelvis. Although these modifications expanded the classical description in many ways, the concepts and key surgical steps are derived from the Hudson procedure. However, there are some gaps or disagreements regarding the anatomical or practical rationale for certain surgical steps. The purpose of this article is to outline the critical steps of radical pelvic cytoreduction ("Hudson procedure"), and to delineate the anatomical basis for the procedure in the proposed form. In addition, we discuss the controversies and address the perioperative morbidity associated with the procedure.

Key words: ovarian cancer, Hudson procedure, anatomical basis, perioperative morbidity

Introduction

Ovarian cancer (OC) is the leading cause of death among all gynecological malignancies, as approximately 70% of patients are diagnosed at advanced stages (1,2). The majority of OC cases are of epithelial type, which mainly spreads through peritoneal dissemination and direct invasion (3). Lymph node spread and hematogenous metastases are also observed, but the main route of dissemination remains peritoneal involvement (1-3). The most impor-

tant prognostic factor for survival is achieving no macroscopic residual disease during surgery (R0). Consequently, current treatment recommendations include optimal debulking surgery (R0) followed by platinum-bases chemotherapy (1-4). Unfortunately, the majority of advanced cases of OC are associated with a "frozen pelvis"- the pouch of Douglas is obliterated by cancerous masses and the ovarian tumor is firmly attached to the surrounding structures, the parietal and visceral peritoneum, uterus, rectum and sigma (1-5). Peritoneal carcinomatosis involving the pelvis is frequently observed, so patients (should) undergo partial or total parietal peritonectomy, usually in conjunction with visceral en-bloc resection (1-5). In 1968, Christopher Hudson introduced a new retroperitoneal surgical technique for fixed ovarian tumors. He developed this operative procedure (called "radical oophorectomy") for removing "an ovarian tumor that is fixed in the pelvis intact with the whole of the peritoneum from surrounding structures still attached" (6). Later, in 1973, Hudson described his personal experience of 25 cases of "radical oophorectomy" and reported one operative death and two fistulas, along with "no other significant morbidity". Contrary to the contemporary approach, although he saw the technique as promising, he suggested that "it may have a place in the management of a few patients with early stage 3 disease" (5-7). In the following years, radical surgical cytoreduction involving the entire peritoneal cavity became the gold standard for the treatment of OC. However, there is no uniform surgical strategy. Many modifications exist in clinical practice and the literature, e.g. complete parietal and visceral peritonectomy, the "cocoon" technique, Bat- shaped en-bloc total peritonectomy (Sarta-Bat approach), en-bloc resection of the pelvis (EnBRP) or en-bloc resection of multivisceral-peritoneal packet (TROMP) (1, 3, 9-12). However, the Hudson procedure remains the cornerstone and reference point for other cytoreductive techniques in fixed ovarian tumors. The purpose of this article is to describe, highlight, and delineate critical surgical steps related to the Hudson procedure, surgical controversies, and perioperative morbidity associated with the procedure are briefly discussed.

Surgical Technique

During the first introduction of the procedure, Hudson assumed that in the majority of cases the operation is feasible without rectosigmoid resection. Subsequently, he reported three cases of rectosigmoid resection among first 25 women who underwent the procedure (6,7). Afterwards, the operations were divided into three different types (1):

Type I – retrograde modified radical hysterectomy with pelvic peritonectomy;
Type II - additional rectosigmoid resection;
Type III – Type I or II with partial resection of the bladder and/or ureter.

In this article, we focus on types I and II with particular attention to practically relevant anatomical and surgical considerations limited to pelvic cytoreduction. As the surgical-anatomical basics of systematic lymphadenectomy have been discussed in detail in our recent publication (13) and since the systematic lymphadenectomy of macroscopically unsuspicious retroperitoneal lymph nodes is no more considered an indispensable part of OC surgery (14), we do not integrate the lymphadenectomy into the present paper. Similarly, since upper abdominal cytoreduction employs general visceral surgical techniques, our review will remain within the confines of the pelvis.

Step 1. Parietal Peritoneum Incision and Retroperitoneal Exposure (Stripping of the Lateral Peritoneum)

The first step of radical pelvic cytoreduction of OC is accessing the retroperitoneum by bilateral paracolic gutter peritoneal incisions, which continue in ventro-medial direction along the posterior margin of the symphysis pubis. In cases of peritoneal carcinomatosis, the incision can be more lateral and superior to the tumor mass. If the pelvic tumor spreads to the extrapelvic peritoneum, the incision

should be extended from the right paracolic gutter up to the hepatocolic ligament. In addition, the root of the mesentery is dissected from the cecum to the Treitz' ligament (15). The lateral peritonectomy proceeds by dissection in the medial and caudal direction along the psoas major muscle. The peritoneum is detached from the fascia transversalis. The surgeon should be aware of the presence of the genitofemoral nerve, which is located over the psoas major muscle. Subsequently, the parietal peritoneum is elevated and retracted medially. The retroperitoneal area is exposed. Round ligaments are ligated and transected retroperitoneally. This should be done as laterally as possible (close to the pelvic sidewall) (1,3,5). The resection lines of the visceral and parietal peritoneum during Hudson procedure are shown in *Fig. 1.*

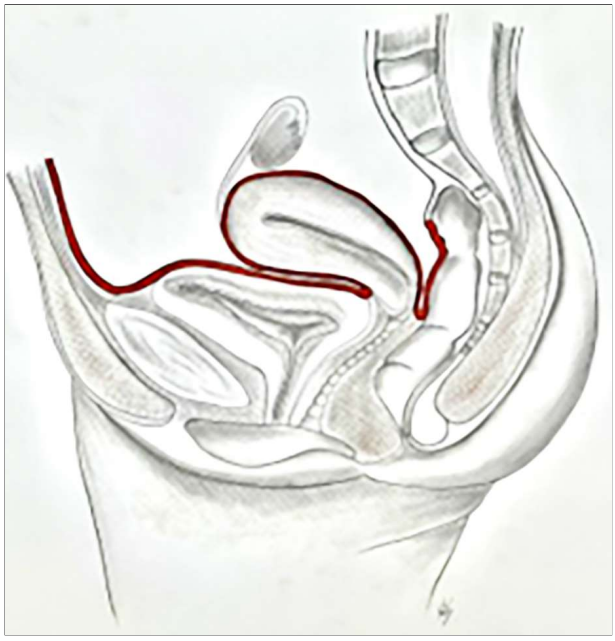


Figure 1. The resection lines of the visceral and parietal peritoneum during Hudson procedure

Step 2. Identification and Preservation of the Ureter and Devascularization of the Tumor

After retroperitoneal exposure, the ureters are identified, dissected and retracted laterally. Additionally, the ureters are held for traction with vasa-loops. The isolation of the ureter enables safe ligation and transection of the infundibulo-pelvic ligaments. It is advisable to ligate the ligaments as high as possible. The first and second step are shown in *Fig. 2.*

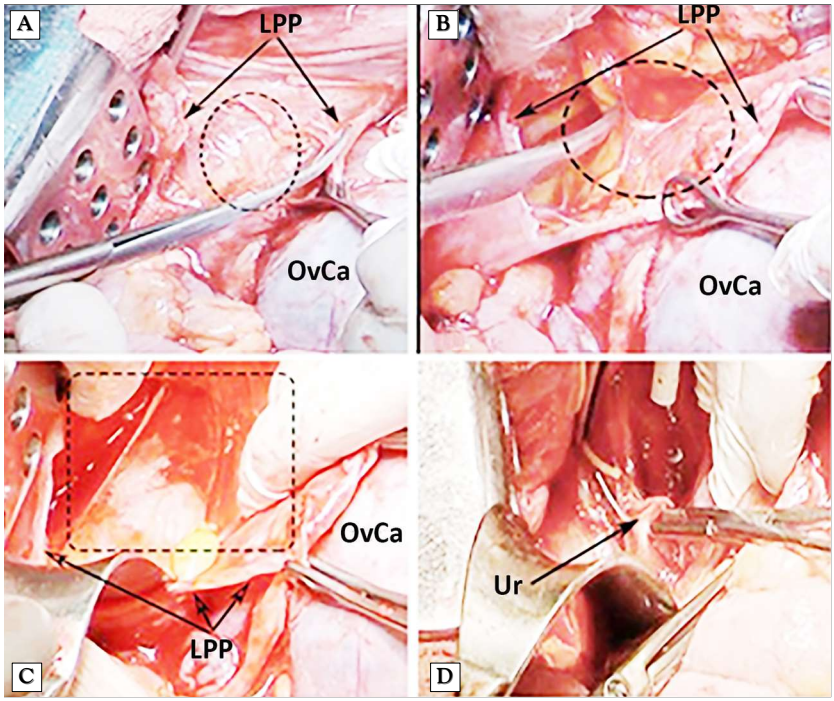


Figure 2. First and second step of the Hudson procedure – case of ovarian tumor firmly adherent to the uterus and completely obliterating the pouch of Douglas. The ovarian pedicle is ligated and divided after mobilization of the ureter (left side of the pelvis). **(A, B)** – lateral peritonectomy; **(C)** – retroperitoneal exposure; **(D)** – identification of the ureter. LPP - lateral parietal peritoneum, OvCa – ovarian cancer, Ur - ureter

Step 3. Pararectal and Paravesical Space Development

The ureter divides the pararectal space into two pararectal spaces – the medial pararectal space (Okabayashi space) and the lateral pararectal space (Latzko space). The Okabayashi space is limited ventrally by the cardinal ligament, dorsally by the ventrolateral aspect of the sacrum, medially by the sacrouterine ligament, and laterally by the ureter, mesoureter, and hypogastric nerve. The Latzko's space is limited ventrally by the cardinal ligament, dorsally by the sacrum, medially by the ureter and laterally by the internal iliac artery (16).

The umbilical ligament divides the paravesical space into two spaces, the lateral and the medial paravesical space. Boundaries of the lateral paravesical space are: laterally – external iliac vessels; medially – umbilical ligament; dorsally – cardinal ligament and ventrally – superior pubic ramus. The lateral limit of the medial paravesical space is the umbilical ligament and the medial limit is the bladder. Other boundaries are the same as for the lateral paravesical space (16).

The cardinal ligament separates the pararectal and paravesical spaces. The development of these spaces allows the identification of the uterine artery and the precise dissection of the ureter in the cardinal ligament. Step 3 is shown in *Fig. 3*.

Step 4. Ureterolysis

The dissection of the ureter proceeds from the pelvic brim and the medial side of the pelvic peritoneum to the cardinal ligament, where the uterine artery crosses the ureter (until the ureteric tunnel of Wertheim). This step is mandatory if the tumor is firmly attached to the pelvic sidewall. The ureter can be entirely mobilized from the cardinal ligament just before it enters between the anterior and posterior leaf of the vesicouterine ligament (also known as the anterior parametrium). It is also advisable to dissect the ureters from the anterior leaf of the vesicouterine ligament. Hence, the ureters will be visible during the retrograde dissection and transection of the cardinal ligaments.

Step 5. Uterine Artery Ligation

The previous two steps allow the ligation and transection of the uterine artery where it overlies the ureter. Dividing the uterine arteries at this level has a major advantage as it enables further lateral displacement of the ureter from the tumor. Steps 4 and 5 are shown in *Fig. 4*.

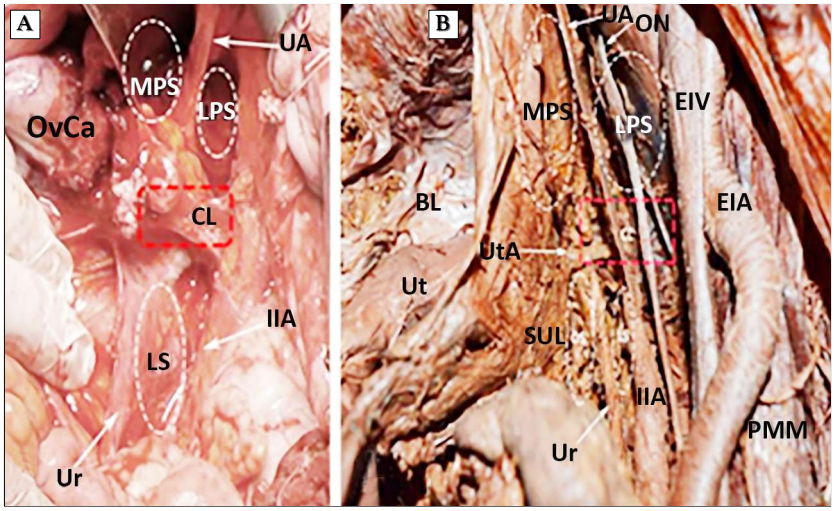


Figure 3. Step 3, paravesical and pararectal space development (right side of pelvis).
(A) – Access by open surgery; **(B)** - embalmed cadaver. LPS – lateral paravesical space, MPS – medial paravesical space, LS – Latzko space; OS - Okabayashi space; CL – cardinal ligament; IIA – internal iliac artery; OvCa – ovarian carcinoma; Ur – ureter; UA – umbilical artery; ON – obturator nerve; SUL – sacrouterine ligament; PMM – psoas major muscle; Ut – uterus; EIA – external iliac artery; EIV – external iliac vein; BL – bladder; UtA- uterine artery

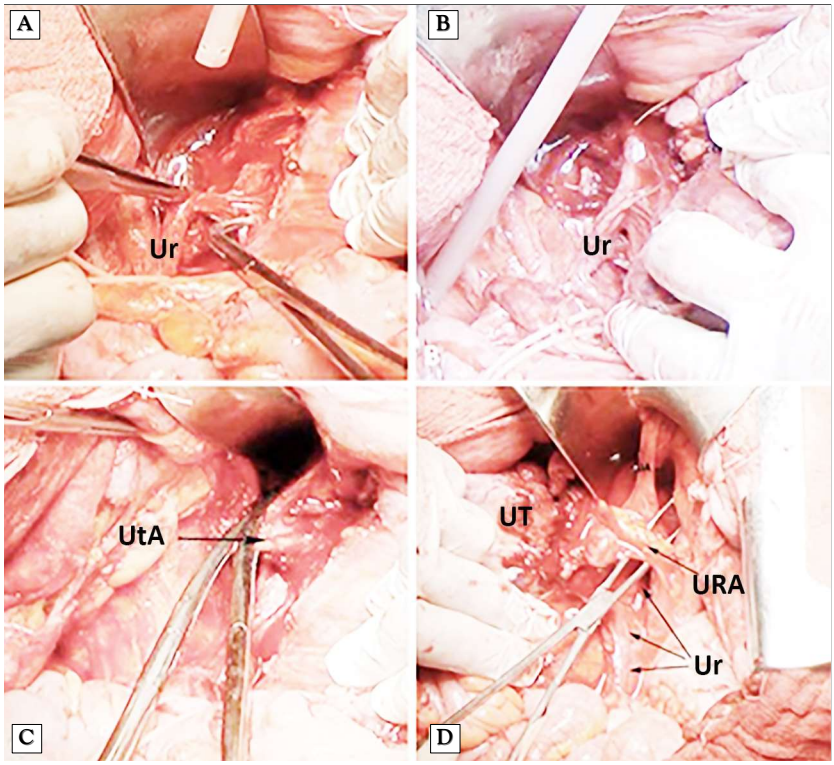


Figure 4. Steps 4 and 5. **(A, B)** – Ureterolysis (left side of pelvis) **(C)** – Uterine artery ligation above ureter (left side of pelvis) **(D)** – The ureter is dissected from the entire cardinal ligament (lateral parametrium). The step is further followed by ligating the uterine artery just above the ureter (right side of pelvis).

Step 6. Presacral Space Development

The limits of the presacral space are: ventrally – posterior rectal wall; dorsally – promontory; laterally - common iliac vessels (right – common iliac artery; left- common iliac vein). There are two approaches for the presacral space – the inter-fascial approach and trans-mesorectal approach. The first approach is used in gynecologic oncology and rectal surgery and is known as the "holy plane of dissection" (this approach is used in total mesorectal excision (TME) – a standard surgical technique for treatment of rectal cancer), whereas the second approach is preferable for surgery of deep endometriosis. However, the second approach is also applicable during this procedure. The presacral space is developed until its caudal limit – the pelvic floor (16). Step 6 is shown in *Fig. 5*.

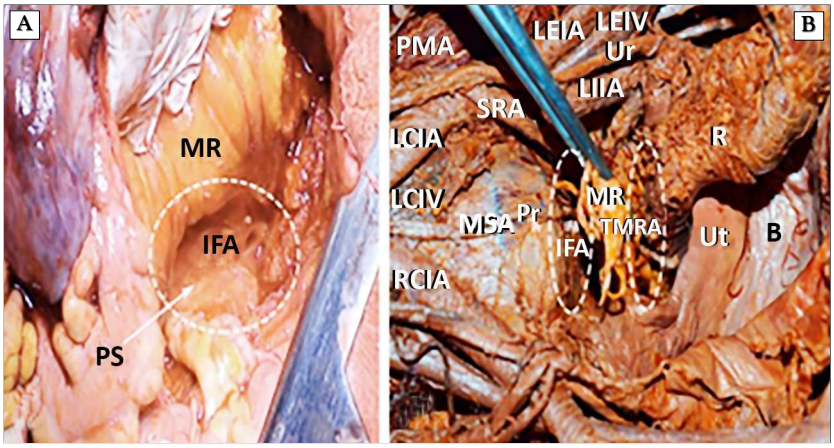


Figure 5. Step 6 – development of the pre-sacral space. A – development of the presacral space – inter-fascial approach (open surgery-right pelvic sidewall). B- possible planes of dissection of the presacral space (embalmed cadaver). MR – mesorectum; PS – presacral space; IFA- inter-fascial approach; TMRA – trans-mesorectal approach; PMM – psoas major muscle, MSA – median sacral artery; Ut –uterus; R – rectum; Pr – promontory; SRA – superior rectal artery; LIIA – left internal iliac artery; LCIV – left common iliac vein; RCIA – right common iliac artery; LCIA – left common iliac artery; LEIV – left external iliac vein; B – bladder.

Step 7. Stripping of the Anterior Peritoneum and Vesicouterine/Vesicovaginal Space Development

A precise plan of dissection should be followed – between the detrusor muscle and the fatty tissue of the anterior peritoneum (15). The stripping proceeds in ventro-caudal and latero-medial direction until the caudal limit of dissection is reached – the anterior wall of the vagina. Dissection of the vesicouterine/vesicovaginal space facilitates this step. Both spaces lie in the same axis. The limits of the vesicovaginal space are: ventrally – bladder; dorsally – pubocervical fascia, anterior wall of the vagina; laterally – cranial portion of vesicouterine ligament (16). Step 7 is shown in *Fig. 6*.

Step 8. Anterior Colpotomy

Intraoperative bimanual examination facilitates the correct site of the vaginal incision. During bimanual examination, a gauze pad can be inserted into the vagina (17). Hence, a transverse anterior incision, e.g., using a monopolar device, is made at the anterior vaginal wall. To avoid extensive bleeding during this step, hemostatic sutures can be placed at cervicovaginal branches.

Step 9. Posterior Colpotomy and Rectovaginal Space Dissection

The posterior wall of the vagina is incised and the rectovaginal space is developed. It is limited ventrally by the posterior vaginal wall, dorsally by the anterior rectal wall and laterally by the sacrouterine ligaments. At the end of step 9, the vagina cuff is closed.

Step 10. Retrograde Dissection

The remaining cardinal and sacrouterine ligaments are ligated and transected proximally to the uterus in retrograde fashion under the guidance of the rectovaginal space. The ureters should always be visible and lateralized during this step. Steps 8, 9, and 10 are shown in *Fig. 7*.

Step 11. Rectal Shaving or Colorectal Anastomosis

In cases where the rectum could be preserved, the peritoneum of pouch of Douglas is dissected from the anterior rectal wall.

In cases of rectosigmoid resection or low rectal resection followed by anastomosis, the sigmoid colon is transected 5 cm above the level of the most proximal part of the tumor.

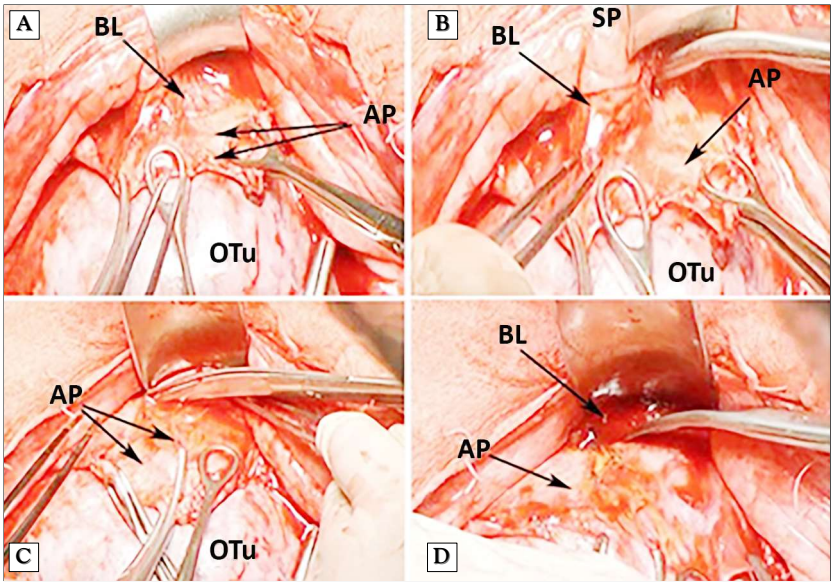


Figure 6. Step 7 – Prevesical peritonectomy and exposure of the vesicovaginal space. A, B, C – stripping of the anterior peritoneum. D – caudal dissection exposed the vesicouterine and vesicovaginal spaces. AP - anterior peritoneum; OTu - ovarian tumor; BL – bladder; SP – symphysis pubis.

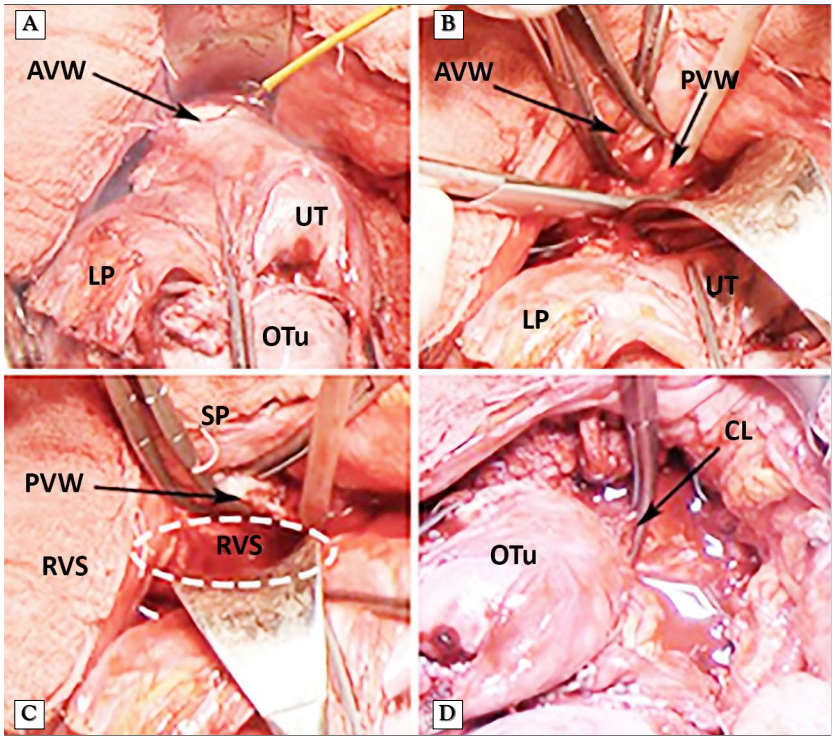


Figure 7. Step 8, 9, and 10. **(A)** - anterior colpotomy; **(B, C)** – posterior colpotomy and development of the rectovaginal space; **(D)** – retrograde resection of sacrouterine ligaments and cardinal ligaments proximally to the uterus. LP – lateral peritoneum; AVW- anterior vaginal wall; UT – uterus; OTu - ovarian tumor; PVW – posterior vaginal wall; RVS – recto-vaginal space; CL – cardinal ligament

The rectum is then detached 2-3 cm from the distal mesorectal tissue. Recto-sigmoid end to end anastomosis is performed by using the staple-line (1,15,17). Step 11 is shown in *Fig. 8*.

Discussion

Preoperative assessment and risk factors predicting postoperative morbidity

Preoperative assessment of patients undergoing radical pelvic debulking (Hudson

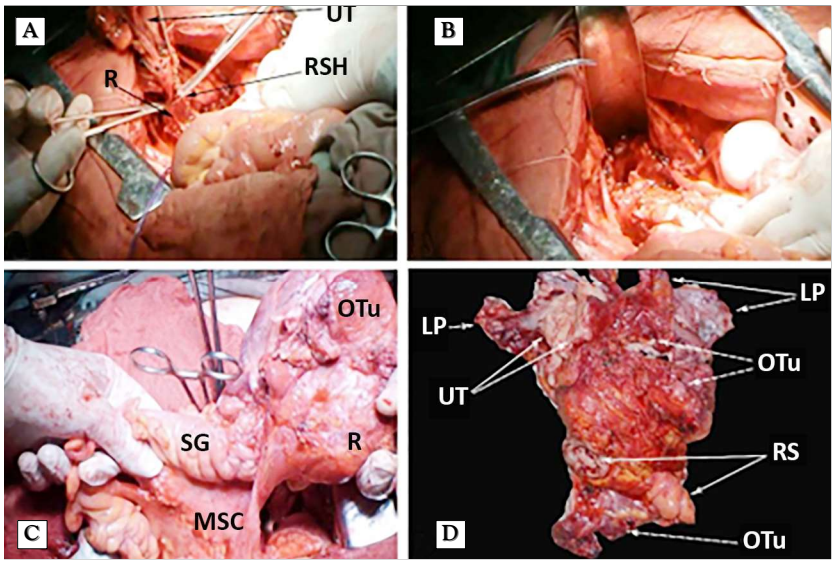


Figure 8. Step 11 – **(A)** - Preservation of the rectum. The peritoneum covering the pouch of Douglas is dissected from the anterior rectal wall; **(B)** - the surgical field after completion of "radical oophorectomy"; **(C)** – preparation for rectosigmoid resection and colorectal anastomosis. The sigmoid mesocolon is dissected and divided. **(D)** – the postoperative specimen after radical oophorectomy combined with recto-sigmoid resection. UT – uterus; RSH – rectal shaving of the anterior abdominal wall; R – rectum; OTu – ovarian tumor; SG- sigma; MSC – mesocolon; LP – lateral peritoneum; RS – rectosigmoid colon

procedure) combined with upper abdominal surgery is indicated to minimize postoperative morbidity (17). Oncogynecologists should be familiar with the principles of peri-operative management as summarized, for example, in the European Society of Gynecological Oncology (ESGO) guidelines which adapt general ERAS (Enhanced Recovery After Surgery) rules to the specifics of OC surgery (18). Multimodal prehabilitation programs improve the post-operative course and time to chemotherapy in patients undergoing radical surgery for advanced OC (19).

Postoperative morbidity is defined as any adverse effect within 30 days after surgery, often assessed using e.g., the Clavien-Dindo classification (21, 21). Kumar et al. examined 620 patients with stage III/IV epithelial OC who underwent primary debulking surgery of which 138 had Clavien-Dindo grade ≥ 3 complications. Authors estimated that the rate of surgical complications depends on age, albumin levels (< 3.5 g/dL), surgical complexity, stage of the disease, ASA (score ≥ 3), and BMI (22). However, Kengsakul et al. performed a systematic review and meta-analysis and reported that only performance status and hypoalbuminemia were the most important risk factors associated with postoperative complications (23). Additionally, the 5-factor modified frailty index (mFI) should be estimated as it predicts postoperative complications, readmissions, non-home discharge and mortality. The mFI includes five factors: hypertension, which requires medication, partially dependent or dependent functional status, insulin-dependent diabetes, chronic obstructive pulmonary disease, and congestive heart failure (24,25).

Diagnostic Laparoscopy

Diagnostic laparoscopy may predict the resectability of advanced OC and its integration into decision-making algorithms has been postulated (26). Various laparoscopic scoring systems have been proposed to predict surgical outcome and resectability in patients with advanced OC, the most widely used being the Fagotti score or the Sugarbaker's Peritoneal Cancer Index score (27-30). However, the British Gynaecological Cancer Society guidelines for OC state that the routine use of laparoscopy to define pre-treatment histology and to predict resectability of the disease is not recommended (31). Likewise, the latest Cochrane review is inconclusive regarding the role of diagnostic laparoscopy prior to treatment (32). Despite the controversies, diagnostic laparoscopy can rule out possible differential diagnoses, e.g., abdominal metastases from other non-gynecological primary tumors or the peritoneal spread of abdominal tuberculosis (*Fig. 9*) (3).

Initial Upper Abdomen Evaluation

As mentioned above, the goal of primary cytoreduction in OC is no visible disease at the end of the surgery. Since OC is an intraperitoneally spreading disease, limiting the surgery to the pelvis in the sense of Hudson's original "radical oophorectomy" is obsolete. Evaluation of the upper abdomen during diagnostic laparoscopy and integration of upper abdominal organs and peritoneal surfaces into surgical algorithm is mandatory (3,11).

Surgical Controversies

There are many controversies regarding surgical steps of the procedure that have never been discussed.

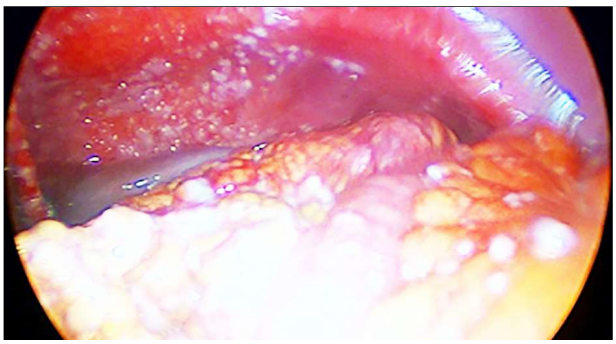


Figure 9. Miliary tuberculosis at the parietal and visceral peritoneum mimicking OC (diagnostic laparoscopy – right upper quadrant diaphragm).

Defining the order of surgical steps

The literature reports different sequences of surgical steps during the procedure. For instance, some surgeons ligate and transect ovarian pedicles at the beginning of the procedure, while others do so later (1,2,5,33, 34,35). Ligation (or bipolar sealing) of the infundibulopelvic ligament should be performed early in the procedure, immediately after ureter identification. This leads to a substantial devascularization of the tumor. Our approach corresponds to the experience of Sznurkowski, who reported performing a central ligation of the vessels supplying the tumor bed at the beginning of the procedure, prior to an en-bloc pelvic resection (2). Obviously, any transection of the infundibulopelvic ligament should always be preceded by ureter identification.

Avascular spaces development

Five avascular spaces are developed during the procedure (13).

Paravesical space

Many authors describing radical cytoreduction for OC do not mention which paravesical space needs to be developed –lateral, medial or both. Both paravesical spaces should be dissected. The lateral paravesical space allows access to the pelvic sidewall in cases of tumors firmly attached to the lateral aspect of the superior pubic ramus. Additionally, this space, together with the pararectal space, will better delineate the cardinal ligament (lateral parametrium). Because the medial border of the medial paravesical space is the bladder, developing this space helps to prevent bladder injury. The development of the medial paravesical space provides lateral access to the vesicovaginal space in cases of its obliteration by the tumor.

Pararectal space

The next contentious issue is whether or not to develop the Okabayashi's space, as many authors do not address this point. The dissection of the Okabayashi space helps to identify the hypogastric nerves and avoid possible injury with consequent neurological postoperative complications. The lateral border of the Okabayashi space (ureter, mesoureter, and hypogastric nerve) should be medialized during dissection.

Retzius space

Some authors develop the Retzius space just prior to anterior peritonectomy, while others abandon this step (1,2). Generally, developing the Retzius space is unnecessary. The dissection plane lying between the detrusor and the anterior parietal peritoneum is beyond the limits of the prevesical space. Furthermore, the following vessels could be injured during dissection of the prevesical space – Santorini veins, dorsal vein of the clitoris, anastomotic branches of both obturator vessels, branches of the internal pudendal artery and the internal pudendal vein. However, in cases of severe carcinomatosis in anterior peritoneum, developing of the Retzius space can be useful for providing better access to the anatomical boundaries of the bladder and avoiding its injury during dissection.

Presacral space

The plane of dissection of the presacral space depends on the surgeon's preference for either the interfascial approach or the trans-mesorectal approach. The main question is whether to preserve the mesorectum and its vessels and nerves. The trans-mesorectal approach is developed during close rectal dissection (CRD), where the mesorectum is preserved. Hudson described the inter-fascial approach with mesorectum removal as "mobilization of the rectum which is later allowed to fall back into the hollow of sacrum".TME is a common surgical procedure for rectal cancer in which the mesorectum is removed. Studies showed that this type of surgery is associated with a lower rate of locoregional recurrences (35). However, Kim et al. concluded that these findings may not be valid for OC surgery due to different patterns of OC spread than colorectal cancer (33). In contrast to Kim et al. other authors noted that once OC has infiltrated the rectal wall, the

pattern of lymphatic spread may be similar to that of primary rectal cancer (36-38).Son et al. compared 163 patients with advanced OC, of whom 87 underwent CRD and 76 underwent TME. The authors concluded that CRD might be an alternative surgical procedure as it was associated with decreased perioperative morbidity (fewer cases of anastomotic leakage and a lower incidence of prolonged ileus over 7 days compared to TME) and similar oncological outcomes (39). Alcazar et al. investigated 60 women with OC who underwent type II Hudson procedure and mesorectal resection. Pathologic examination revealed tumor dissemination to the mesorectum (either through lymph node involvement or directly) in 83% of cases. However, the authors found in multivariate analysis that only carcinomatosis increased the risk of death and the most important prognostic factors remained complete or optimal cytoreduction (40). Additionally, an alternative surgical technique called rectosigmoid mesorectal-sparing resection could be performed in selected cases. Rosati el al. reported that this procedure could maximize blood supply to the rectosigmoid anastomosis and minimize the risk of anastomotic leakage (41). Furthermore, this approach can help to prevent complications related to autonomic nervous system damage such as persistent urinary, defecatory, and sexual dysfunction (41, 42). So far, the correct plane of dissection and the type of surgery are still debatable.

Regarding lateral ligaments of the rectum, it should be emphasized that they should be dissected proximally to the rectum, because distal resection can lead to nerve injuries since the pelvic plexus - also known as the superior hypogastric plexus - is located slightly caudal to these ligaments (16).

Uterine artery ligation

Sznurkowski recommends ligating of the uterine arteries directly at their origin at the internal iliac artery, which would facilitate the excision of the entire parametrium (2). However, we consider such an approach to be too radical, as it leads to injury to the pelvic splanchnic nerve fibers (they pass beneath the deep uterine vein) and parametrial resection is rarely necessary.

Surgical Morbidity

The rate of intra- and postoperative complications varies in the literature (1-3,11,15,40). The majority of authors used the Clavien-Dindo classification for surgical morbidity (19). Tozzi et al. reported an overall morbidity rate of 33% in 92 patients who underwent en-bloc pelvic resection (11). Bristow et al. reported 12.9% major and 35.5% minor complications among 31 women in whom the Hudson procedure was performed (1). Panici et al. operated on 66 patients using the same surgical approach. The authors observed 9% severe and 24% mild complications (15).

However, it is difficult to accurately estimate the true incidence of surgical morbidity directly associated with the pelvic part of cytoreduction (Hudson procedure) as it is usually combined with upper abdomen surgery (1-3,11,15,40). Most articles have discussed how to prevent the most challenging complications of the procedure – anastomotic leak after colorectal anastomosis (43-45). For this reason, we discuss this topic in detail in the following paragraph.

Type of colorectal anastomosis

Three types of colorectal anastomoses are used during bowel resection in OC surgery: end-to-end, side-to-end, and colonic J-pouch (43-47). A systematic review and meta-analysis showed that end-to-side anastomosis significantly reduced the risk of anastomotic leak in patients with rectal cancer treated with low anterior rectal resection (46). In addition, Parc et al. conducted a randomized controlled trial comparing the morbidity and quality of life of patients with a J-Pouch or a side-to-end anastomosis after low anterior rectal resection. The authors found no difference between the two types of anastomoses in terms of morbidity and functional outcome at 1 or 2 years postoperatively. They concluded that side-to-end anastomosis might

be chosen due to the ease of construction (47). Nevertheless, OC is a completely different disease and studies showed that there was no significant difference in major morbidity following end-to-end or end-to-side anastomosis (45,48). Therefore, prospective randomized trials are needed, focusing in particular on colorectal anastomosis in OC surgery.

Risks factor for anastomotic leak

The incidence of an anastomotic leak in OC surgery after colorectal resections is lower compared to operations for rectal cancer (44-48). Two recent studies from the field of gynecological-oncological surgery report an incidence of anastomotic leak of 2.9% and 6.6%, respectively (44, 45). Lago et al. performed a retrospective multi-center study, which included 457 patients (in the final multivariate analysis) undergoing OC surgery with colorectal resection and anastomosis (44). The authors found the following independent risk factors to be directly associated with a higher likelihood of anastomotic leak: age at the time of surgery, serum albumin level, multiple small bowel resections, hand-sewn anastomosis, and distance to the anal verge (44). Constatini et al. retrospectively analyzed data from 515 patients undergoing colorectal resection with anastomosis for advanced OC. The authors found the following independent risk factors for anastomotic leak: body mass index (< 18 kg/m2), serum albumin level < 30 mg/dl, ligation and transection of the inferior mesenteric artery at its origin and colorectal anastomosis less than 10 cm from the anal verge (45).

Prophylactic intestinal diversion

Prophylactic intestinal diversion (PID) has been shown to be unnecessary in recto-sigmoid resection and primary anastomosis, as the rate of anastomotic leakage in OC cases without PID remains acceptably low (11,18, 43). Studies showed that PID did not actually reduce the rate of anastomotic leak, but only increased the incidence of postoperative sepsis and re-laparotomy (43,44,49,50). Additionally, the PID can promote dehydration, malnutrition, and renal impairment (43,44). However, Koscielny et al. mentioned that protective loop ileostomy could be implemented for selected bevacizumab-treated patients with colorectal anastomosis and OC surgery (49). Recently, the ghost ileostomy has been introduced into gynecological-oncological surgery (51). The ghost ileostomy does not have the disadvantages of the PID (44,51). Similarly, Lago et al. reported that ghost ileostomy is superior to PID and can be used in patients with one risk factor for anastomotic leak, in contrast to patients with multiple risk factors, for whom PID appears more appropriate (44). Nevertheless, future prospective trials are needed to assess the role of PID or ghost ileostomy in gynecological oncological surgery.

Low anterior resection syndrome

Low anterior resection syndrome (LARS) is a common long-term complication after low anterior rectal resection. LARS includes uncoordinated bowel movement, diarrhea or constipation, incomplete emptying, and incontinence of flatus and/or faeces (52-54). A specific LARS score assesses its severity and divides into three categories ("absent", "minor", and "major" LARS) (53). Notably, the risk factors for LARS after OC surgery differ from those after colorectal surgery, so they are not clear. Patients with rectal cancer differ in terms of type of surgery and adjuvant or neoadjuvant treatment, whereas women with ovarian cancer surgery, often received en-bloc pelvic resection combined with upper abdominal surgery (52). A recent multi-center comparative cohort study compared LARS in patients undergoing low anterior resection for OC and women who were operated for rectal cancer. The authors noted that LARS is under-reported after OC surgery. They also concluded that the functional outcome was similar to women with low anterior resection for rectal cancer who did not receive radiotherapy (54). Smit et al. studied 47 patients undergoing debulking surgery with low anterior rectal resection. The authors observed symptoms of LARS in 76.6% of the women. They concluded that the evidence on LARS in OC surgery is

limited (55). Another prospective longitudinal study reported that LARS-like symptoms could be observed in one third of the women preoperatively. The authors found that this could help identify high-risk patients for LARS postoperatively (56). Another study reported a 37.9% incidence of major LARS in OC patient with low anterior rectal resection. The authors also noticed that multiple bowel anastomoses were a risk factor for LARS (57). Because LARS is a common and significant postoperative complication, further studies are needed to estimate the majority of risk factors and to reduce their incidence.

Conclusion

Identifying the ureter and ligating the ovarian vessels should be the initial step of the procedure. The development of avascular spaces is a critical step in pelvic cytoreduction. These spaces provide additional access and help better identify anatomical structures in the retroperitoneum. In addition, controlling pelvic hemorrhage is easier when all potential spaces near the surgical field are dissected. Development of Okabayashi's pararectal space, ligation of the uterine artery above the ureter and proximal transection of the lateral ligament of the rectum (in the case of a rectosigmoid anastomosis) help to preserve the patient's pelvic innervation.

Conflicts of Interest

The authors declare no competing interests.

Funding

This research received no external funding.

Author's Contributions

Conceptualization: S.K. and R.W.; methodology: S.K., A.Y., R.W., Y.I..; formal analysis: Y.K., S.S., Y.I., S.K; investigation: S.K., R.W., V.I.; resources: Y.I. and S.K.; data curation: S.S., Y.I.; writing—original and draft preparation,: S.K.; writing—review and editing, S.S., Y.I., Y.K.; visualization: R.W. and Y.K.; supervision: A.Y. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The authors declare that all related data are available concerning researchers by the corresponding author's email.

References

1. Bristow RE, del Carmen MG, Kaufman HS, Montz FJ. Radical oophorectomy with primary stapled colorectal anastomosis for resection of locally advanced epithelial ovarian cancer. J Am Coll Surg. 2003;197(4):565-74.
2. Sznurkowski JJ. En bloc pelvic resection for advanced ovarian cancer preceded by central ligation of vessels supplying the tumor bed: a description of surgical technique and a feasibility study. World J Surg Oncol. 2016;14:133.
3. Khatib G, Seyfettinoglu S, Guzel AB, Gulec UK, Unlugenc H, Vardar MA. Feasibility and rationale of a novel approach in advanced ovarian cancer surgery: Bat- shaped en-bloc total peritonectomy and total hysterectomy salpingo-oophorectomy with or without rectosigmoid resection (Sarta-Bat approach). Gynecol Oncol. 2021;161(1):97-103.
4. Chi DS, Eisenhauer EL, Lang J, Huh J, Haddad L, Abu-Rustum NR, et al. What is the optimal goal of primary cytoreductive surgery for bulky stage IIIC epithelial ovarian carcinoma (EOC)? Gynecol Oncol. 2006;103:559–64
5. Selcuk İ, Ersak B, Kılıç F, Toyran A, Şahin Aker S, Özdal B, Yalçın HR. The role of pelvic avascular spaces in en-bloc hysterectomy and total pelvic parietal peritonectomy procedure with anatomical considerations. Türk Kadın Sağlığı ve Neonatoloji Dergisi. 2020;2(1):27-30
6. Hudson CN. A radical operation for fixed ovarian tumours. J Obstet Gynaecol Br Commonw. 1968;75(11):1155-60.
7. Hudson CN, Chir M. Surgical treatment of ovarian cancer. Gynecologic Oncology 1973;1(4):370–378.
8. William Helm C. Hudson's landmark contribution to ovarian cancer surgery. BJOG. 2016;123(13):2190.
9. Sugarbaker PH. Complete parietal and visceral peritonectomy of the pelvis for advanced primary and recurrent ovarian cancer. Cancer Treat Res 1996; 81:75–87
10. Kyriazanos I, Papageorgiou D, Zoulamoglou M, Marougkas M, Stamos N, Ivros N, et al. Total extraperitoneal access for parietal peritonectomy for peritoneal surface malignancy: The 'cocoon' technique. Eur J Obstet Gynecol Reprod Biol. 2020;251:258-262.
11. Tozzi R, Hardern K, Gubbala K, Garruto Campanile R, Soleymani Majd H. En-bloc resection of the pelvis (EnBRP) in patients with stage IIIC-IV ovarian cancer: A 10 steps standardised technique. Surgical and survival outcomes of primary vs. interval surgery. Gynecol Oncol. 2017;144(3): 564-570.
12. Muallem MZ, Sehouli J, Miranda A, Richter R, Muallem J. Total retroperitoneal en bloc resection of multivisceral-peritoneal packet (TROMP operation): a novel surgical technique for advanced ovarian cancer. Int J Gynecol Cancer. 2020;30(5):648-653.
13. Kostov S, Selçuk I, Yordanov A, Kornovski Y, Yalçın H, Slavchev S, et al. Paraaortic Lymphadenectomy in Gynecologic Oncology-Significance of Vessels Variations. J Clin Med. 2022;11(4):953.
14. Harter P, Sehouli J, Lorusso D, Reuss A, Vergote I, Marth C et al. A Randomized Trial of Lymphadenectomy in Patients with Advanced Ovarian Neoplasms. N Engl J Med. 2019;380(9):822-832.
15. Benedetti-Panici P, Maneschi F, Scambia G, Cutillo G, Greggi S, Mancuso S. The pelvic retroperitoneal approach in the treatment of advanced ovarian carcinoma. Obstet Gynecol. 1996;87(4):532-8.

16. Kostov S, Slavchev S, Dzhenkov D, Mitev D, Yordanov A. Avascular Spaces of the Female Pelvis - Clinical Applications in Obstetrics and Gynecology. J Clin Med. 2020;9(5):1460.
17. Ramirez PT, Abu-Rustum NR, Frumovitz M. Dedication, Editor(s): Pedro T. Ramirez, Michael Frumovitz, Nadeem R. Abu-Rustum, Principles of Gynecologic Oncology Surgery. Elsevier; 2018. p. 5, pp – 178-181.
18. Fotopoulou C, Planchamp F, Aytulu T, Chiva L, Cina A, Ergönül Ö et al. European Society of Gynaecological Oncology guidelines for the peri-operative management of advanced ovarian cancer patients undergoing debulking surgery. Int. J. Gynecol. Cancer. 2021;31:1199–1206.
19. Dhanis J, Keidan N, Blake D, Rundle S, Strijker D, van Ham M, Pijnenborg JMA, Smits A. Prehabilitation to Improve Outcomes of Patients with Gynaecological Cancer: A New Window of Opportunity? Cancers (Basel). 2022;14(14):3448.
20. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205-13.
21. Watrowski R, Kostov S, Alkatout I. Complications in laparoscopic and robotic-assisted surgery: definitions, classifications, incidence and risk factors - an up-to-date review. Wideochir Inne Tech Maloinwazyjne. 2021;16(3):501-525.
22. Kumar A, Janco JM, Mariani A, Bakkum-Gamez JN, Langstraat CL, Weaver AL et al. Risk-prediction model of severe postoperative complications after primary debulking surgery for advanced ovarian cancer. Gynecol Oncol. 2016;140(1):15-21.
23. Kengsakul M, Nieuwenhuyzen-de Boer GM, Udomkarnjananun S, Kerr SJ, Niehot CD, van Beekhuizen HJ. Factors predicting postoperative morbidity after cytoreductive surgery for ovarian cancer: a systematic review and meta-analysis. J Gynecol Oncol. 2022;33(4):e53.
24. Hermann CE, Koelper NC, Andriani L, Latif NA, Ko EM. Predictive value of 5-Factor modified frailty index in Oncologic and benign hysterectomies. Gynecol Oncol Rep. 2022;43:101063.
25. AlHilli MM, Schold JD, Kelley J, Tang AS, Michener CM. Preoperative assessment using the five-factor modified frailty index: A call for standardized preoperative assessment and prehabilitation services in gynecologic oncology. Gynecol Oncol. 2022;166(3):379-388.
26. Di Donna MC, Cucinella G, Zaccaria G, Lo Re G, Crapanzano A, Salerno S et al. Concordance of Radiological, Laparoscopic and Laparotomic Scoring to Predict Complete Cytoreduction in Women with Advanced Ovarian Cancer. Cancers (Basel). 2023;15(2):500.
27. Engbersen MP, Lahaye MJ, Lok CAR, Koole SN, Sonke GS, Beets-Tan RGH, Van Driel WJ. Peroperative scoring systems for predicting the outcome of cytoreductive surgery in advanced-stage ovarian cancer - A systematic review. Eur J Surg Oncol. 2021;47(8):1856-1861.
28. Fagotti A, Ferrandina G, Fanfani F, Ercoli A, Lorusso D, Rossi M, Scambia G. A laparoscopy-based score to predict surgical outcome in patients with advanced ovarian carcinoma: a pilot study. Ann Surg Oncol. 2006;13(8): 1156-61.
29. Jacquet P, Sugarbaker PH. Current methodologies for clinical assessment of patients with peritoneal carcinomatosis. J Exp Clin Cancer Res. 1996;15:49Y57
30. Lampe B, Kroll N, Piso P, Forner DM, Mallmann P. Prognostic significance of Sugarbaker's peritoneal cancer index for the operability of ovarian carcinoma. Int J Gynecol Cancer. 2015;25(1):135-44. .
31. Fotopoulou C, Hall M, Cruickshank D, Gabra H, Ganesan R, Hughes C et al. British Gynaecological Cancer Society (BGCS) epithelial ovarian/fallopian tube/primary peritoneal cancer guidelines: recommendations for practice. Eur J Obstet Gynecol Reprod Biol. 2017;213:123-139.
32. Rutten MJ, Leeflang MM, Kenter GG, Mol BW, Buist M. Laparoscopy for diagnosing resectability of disease in patients with advanced ovarian cancer. Cochrane Database Syst Rev. 2014;2014(2):CD009786.
33. Kim MS, Noh JJ, Lee YY. En bloc pelvic resection of ovarian cancer with rectosigmoid colectomy: a literature review. Gland Surg. 2021;10(3): 1195-1206.
34. Angeles MA, Martínez-Gómez C, Martinez A, Ferron G. En bloc pelvic resection for ovarian carcinomatosis: Hudson procedure in 10 steps. Gynecol Oncol. 2019;153(1):209-210.
35. Tejerizo-Garcia A, Olloqui A, Lopez G, Alvarez-Conejo C, Caso-Maestro O, Diez A. Step-by-step total pelviperitonectomy with modified posterior pelvic exenteration. Int J Gynecol Cancer. 2020;30(4):558.
36. Kumagai K, Okamura T, Toyoda M, Senzaki H, Watanabe C, Ohmichi M. Rectal lymph node metastasis in recurrent ovarian carcinoma: essential role of 18F-FDG PET/CT in treatment planning. World J Surg Oncol. 2013; 11(1):184.
37. Baiocchi G, Cestari LA, Macedo MP, Oliveira RA, Fukazawa EM, Faloppa CC, Kumagai LY, Badiglian-Filho L, Menezes AN, Cunha IW, Soares FA. Surgical implications of mesenteric lymph node metastasis from advanced ovarian cancer after bowel resection. J Surg Oncol. 2011;104:250-254.
38. Salani R, Diaz-Montes T, Giuntoli RL, Bristow RE: Surgical management of mesenteric lymph node metastasis in patients undergoing rectosigmoid colectomy for locally advanced ovarian carcinoma. Ann Surg Oncol. 2007; 14: 3552-3557.
39. Son JH, Kim J, Shim J, Kong TW, Paek J, Chang SJ, Ryu HS. Comparison of posterior rectal dissection techniques during rectosigmoid colon resection as part of cytoreductive surgery in patients with epithelial ovarian cancer: Close rectal dissection versus total mesorectal excision. Gynecol Oncol. 2019;153(2):362-367.
40. Alcazar JL, Jurado M, Minguez JA, Chacon E, Martinez-Regueira F. En-bloc rectosigmoid and mesorectum resection as part of pelvic cytoreductive surgery in advanced ovarian cancer. J Turk Ger Gynecol Assoc. 2020;21(3): 156-162.
41. Rosati A, Vargiu V, Santullo F, Lodoli C, Attalla El Halabieh M, Scambia G, Fagotti A, Costantini B. Rectosigmoid Mesorectal-Sparing Resection in Advanced Ovarian Cancer Surgery. Ann Surg Oncol. 2021;28(11): 6721-6722.
42. Shan Y, Jin Y, Li Y, Gu Y, Wang W, Pan L. Rectosigmoid sparing en bloc pelvic resection for fixed ovarian tumors: Surgical technique and peri-operative and oncologic outcomes. Front Oncol. 2022;12:980050.
43. Obermair A, Hagenauer S, Tamandl D, Clayton RD, Nicklin JL, Perrin LC et al.Safety and efficacy of low anterior en bloc resection as part of cyto-reductive surgery for patients with ovarian cancer. Gynecol Oncol. 2001; 83(1):115-20.
44. Lago V, Fotopoulou C, Chiantera V, Minig L, Gil-Moreno A, Cascales-Campos PA et al. Risk factors for anastomotic leakage after colorectal resection in ovarian cancer surgery: A multi-centre study. Gynecol Oncol. 2019;153(3):549-554. doi: 10.1016/j.ygyno.2019.03.241
45. Costantini B, Vargiu V, Santullo F, Rosati A, Bruno M, Gallotta V et al. Risk Factors for Anastomotic Leakage in Advanced Ovarian Cancer Surgery: A Large Single-Center Experience. Ann Surg Oncol. 2022;29(8):4791-4802.
46. McKechnie T, Sharma S, Daniel R, Eskicioglu C. End-to-end versus end-to-side anastomosis for low anterior resection: A systematic review and meta-analysis of randomized controlled trials. Surgery. 2021;170(2):397-404.
47. Parc Y, Ruppert R, Fuerst A, Golcher H, Zutshi M, Hull T et al. Better Function With a Colonic J-Pouch or a Side-to-end Anastomosis?: A Randomized Controlled Trial to Compare the Complications, Functional Outcome, and Quality of Life in Patients With Low Rectal Cancer After a J-Pouch or a Side-to-end Anastomosis. Ann Surg. 2019;269(5):815-826.
48. Graham R, Kotsopoulos IC. A comparison of end-to-end and end-to-side anastomosis following rectosigmoid resection in ovarian cancer cytoreductive surgery. Eur J Surg Oncol. 2022:S0748-7983(22)00650-3.
49. Koscielny A, Ko A, Egger EK, Kuhn W, Kalff JC, Keyver-Paik MD. Prevention of Anastomotic Leakage in Ovarian Cancer Debulking Surgery and Its Impact on Overall Survival. Anticancer Res. 2019;39(9):5209-5218.
50. Tseng JH, Suidan RS, Zivanovic O, Gardner GJ, Sonoda Y, Levine DA et al. Diverting ileostomy during primary debulking surgery for ovarian cancer: Associated factors and postoperative outcomes. Gynecol Oncol. 2016; 142(2):217-24.
51. Lago V, Flor B, Matute L, et alGhost Ileostomy in Advanced Ovarian Cancer: A Reliable OptionInternational Journal of Gynecologic Cancer 2018; 28:1418-1426.
52. Aly EH. Low anterior resection syndrome (LARS) in ovarian cancer patients. Int J Surg. 2020;78:170.
53. Emmertsen KJ, Laurberg S. Low anterior resection syndrome score: development and validation of a symptom-based scoring system for bowel

dysfunction after low anterior resection for rectal cancer. Ann Surg. 2012;255(5):922-8.
54. Harpain F, Kranawetter M, Zott T, Lazaridis II, Guenin MO, Ninkovic M, et al. Low anterior resection syndrome (LARS) in ovarian cancer patients - A multi-centre comparative cohort study. Int J Surg. 2020;78:97-102.
55. de Smit NS, Fioole LC, Stiekema A et al. 2022-RA-965-ESGO Prevalence of low anterior resection syndrome in patients with advanced stage epithelial ovarian cancerInternational. J Gynec Cancer 2022;32:A286-A287.
56. Imterat M, du Bois A, Heitz F, Traut A, Harter P, Ataseven B. Low anterior resection syndrome and their impact on life quality in ovarian cancer patient: A prospective longitudinal study (498), Gynecologic Oncology, 2022; Supplt 1: 166
57. Kranawetter M, Ataseven B, Grimm C, Schneider S, Riss S, Alesina P et al. Low anterior resection syndrome (LARS) in patients with epithelial ovarian cancer after primary debulking surgery. Gynecol Oncol. 2019;154(3): 577-582.