JBCR Journal of Biomedical & Clinical Research
Journal of Medical University of Pleven

Journal of Biomedical and Clinical Research 17(2): 205–218 (2024)
DOI: 10.3897/jbcr.e138141

Research Article

The role of minimally invasive surgery in the diagnosis and treatment of ovarian carcinoma

Teodora Semova[1,2], Slavcho Tomov[1,2], Tihomir Totev[1,2], Dimitar Dimitrov[1,2], Zornitsa Gorcheva[1,3], Valeria Racheva[1,4]

1 *Medical University – Pleven, Pleven, Bulgaria*
2 *Department of Obstetrics and Gynecology, University Hospital St. Marina–Pleven, Pleven, Bulgaria*
3 *Department of Gastroenterology, University Hospital St. Marina–Pleven, Pleven, Bulgaria*
4 *Department of Clinical Laboratory, University Hospital St. Marina–Pleven, Pleven, Bulgaria*

Corresponding author: Teodora Semova (teodora_semova@abv.bg)

Summary

Standard treatment for ovarian cancer includes optimal cytoreduction, followed by chemotherapy in most cases. This study aimed to evaluate the role of minimally invasive approaches in diagnosing and treating ovarian carcinoma. We conducted a retrospective analysis of patients diagnosed with ovarian carcinoma who underwent surgery at the Department of Obstetrics and Gynecology at St. Marina University Hospital–Pleven from January 2020 to April 2023. The study included 213 patients; the average age was 58.90 years. Out of all patients in the study, 64 initially received only diagnostic intervention. Of these patients, 53 (24.9%) underwent minimally invasive diagnostic intervention, while 11 (5.2%) had diagnostic intervention through conventional laparotomy. Among the patients who had surgery, the most common procedure (53.1%) was total abdominal hysterectomy with bilateral salpingo-oophorectomy, followed by diagnostic laparoscopy with subsequent laparotomy (14.6%). Thirty-one (14.6%) of the patients had interval surgery. Twenty-seven (87.1%) patients underwent minimally invasive diagnostic intervention. Moreover, 21 (67.7%) patients who had interval surgery also underwent surgery using a minimally invasive approach. The obtained results show that minimally invasive approaches are widely used in the diagnosis and treatment of ovarian carcinoma. The increasing adoption of interval surgery will expand another application of minimally invasive surgery - robot-assisted interval surgery after neoadjuvant chemotherapy.

Key words: Minimally invasive surgery, ovarian cancer, robot-assisted interval surgery

OPEN ACCESS

Academic editor: Pencho Tonchev
Received: 29 September 2024
Accepted: 30 October 2024
Published: 28 November 2024

Citation: Semova T, Tomov S, Totev T, Dimitrov D, Gorcheva Z, Racheva V (2024) The role of minimally invasive surgery in the diagnosis and treatment of ovarian carcinoma. Journal of Biomedical and Clinical Research 17(2): 205–218. https://doi.org/10.3897/jbcr.e138141

Introduction

Ovarian cancer ranks seventh among malignant tumours and eighth as a cause of death from cancer in women globally (Momenimovahed et al. 2019; Gaona-Luviano et al. 2020). The lifetime risk of developing epithelial ovarian carcinoma is 1.3%, but it is as high as 40–45% for women with a BRCA1 mutation and 15–20% for BRCA2 mutation carriers (Norquist et al. 2016). Lynch syndrome is also associated with a higher risk of ovarian cancer. It is caused by mutations in the mismatch repair genes (Chirasophon et al. 2017; Boussios et

al. 2020; Shah et al. 2022). Other risk factors include age, infertility or nulliparity, estrogen hormone treatment, obesity, and endometriosis for endometrioid carcinomas and clear-cell carcinomas.

Approximately 75% of patients are diagnosed with advanced-stage disease. Population-based screening is ineffective, and new approaches for early diagnosis using molecular genomics are still developing (Menon et al. 2021; Pinto et al. 2023). Standard treatment for ovarian cancer includes initial surgery for histological verification, successful staging, and optimal cytoreduction, followed by chemotherapy in most cases.

In the early 1990s, pioneers in the field of laparoscopic surgery utilised minimally invasive techniques to treat gynecologic cancers, including the laparoscopic staging of early ovarian cancer (Nezhat et al. 2013). The role of minimally invasive surgery in gynecologic oncology has expanded in the last several decades and has found broad use in the treatment of endometrial, cervical, and ovarian cancer (Nezhat et al. 2013; Knisely et al. 2021). However, the crucial question regarding the role of the minimally invasive approach in diagnosing and treating ovarian cancer remains to be assessed.

This study aimed to evaluate the role of minimally invasive approaches in diagnosing and treating ovarian carcinoma and to summarise the current evidence available.

Materials and methods

We conducted a retrospective analysis of patients diagnosed with ovarian carcinoma who underwent surgery at the Department of Obstetrics and Gynecology at St. Marina University Hospital – Pleven from January 2020 to April 2023. We gathered data from the clinical records of these patients, which were sourced from the University Hospital database – Gamma Code Master®. Patients who had previously undergone surgery for ovarian carcinoma in another hospital were not included in the analysis.

The diagnostic surgical procedures performed included diagnostic laparoscopy with biopsy, unilateral laparoscopic adnexectomy, bilateral laparoscopic adnexectomy, exploratory laparotomy with biopsy, unilateral conventional open adnexectomy, bilateral conventional open adnexectomy, and robot-assisted bilateral adnexectomy.

The operations performed included total abdominal hysterectomy with bilateral salpingo-oophorectomy, diagnostic laparoscopy followed by open total hysterectomy with bilateral salpingo-oophorectomy, robot-assisted total hysterectomy with bilateral salpingo-oophorectomy, total laparoscopic hysterectomy with bilateral salpingo-oophorectomy, fertility-sparing open adnexectomy, and total hysterectomy with previously removed adnexa.

The tumours were classified pathologically according to the TNM and FIGO classifications. Data was entered and processed using the statistical packages IBM SPSS Statistics 25.0, MedCalc Version 19.6.3, and Excel in Office 2021. The significance level at which the null hypothesis was rejected was set at $p < 0.05$.

The following methods were used:

1. Descriptive analysis: The frequency distribution of the considered indicators is presented in tabular form.

2. Graphical analysis: visualisation of the obtained results.
3. Analysis of variance: estimates of central tendency and statistical dispersion.
4. Comparing relative shares.
5. Fisher-Freeman-Halton exact and %2 test: testing hypotheses about dependence between categorical variables.

Our results were compared with data in the literature.

Results

Between January 2020 and April 2023, the Department of Obstetrics and Gynecology at University Hospital St. Marina-Pleven performed surgical interventions on 213 patients with ovarian carcinoma. The average age of the patients was 58.90 years, with a standard deviation of 12.19 years, ranging from 28 to 85 years. The age group with the largest relative share (29.6%) was 60–69 years, followed by 50–59 years with 25.4%, and the smallest group (< 30 years) accounted for only 0.9% of the patients (Fig. 1).

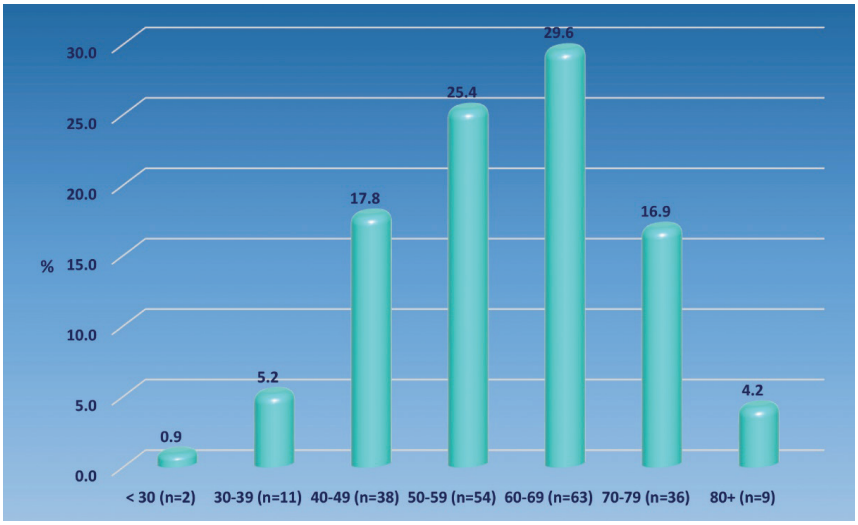

Figure 1. Distribution of study participants by age group.

The study included 54 patients (25.4%) diagnosed with early-stage ovarian carcinoma (I and II FIGO stage). Among them, three patients (5.6%) underwent total laparoscopic hysterectomy with bilateral salpingo-oophorectomy, five patients (9.3%) had robot-assisted total hysterectomy with bilateral salpingo-oophorectomy, and five patients (9.3%) received diagnostic laparoscopy followed by total abdominal hysterectomy with bilateral salpingo-oophorectomy. These minimally invasive surgeries were used in 24.1% of the early-stage ovarian carcinoma cases. Additionally, 39 patients underwent total abdominal hysterectomy with bilateral salpingo-oophorectomy, and two had fertility-sparing open adnexectomy. This shows that in 41 (75.9%) of the patients with early-stage ovarian carcinoma, conventional laparotomy was used for treatment.

Out of all patients in the study, 64 initially received only diagnostic intervention. These patients were considered inoperable and, after histological verification, were referred to chemotherapy. Among these patients, 53 (24.9%) underwent minimally invasive diagnostic intervention, while 11 (5.2%) had diagnostic

intervention through conventional laparotomy. The most common minimally invasive diagnostic intervention was diagnostic laparoscopy with biopsy (14.1%), followed by unilateral laparoscopic adnexectomy (6.1%). Twenty-five patients (11.7% of the entire sample and 76.8% of those who did not have surgery) had only a diagnostic intervention through minimally invasive methods (Table 1).

Table 1. Frequency distribution of patients according to diagnostic intervention.

Type of diagnostic intervention	n	%	Sp
Not done	149	70.0	3.1
Diagnostic laparoscopy with biopsy	30	14.1	2.4
Unilateral laparoscopic adnexectomy	13	6.1	1.6
Bilateral laparoscopic adnexectomy	9	4.2	1.4
Bilateral conventional open adnexectomy	5	2.3	1.0
Exploratory laparotomy with biopsy	3	1.4	0.8
Unilateral conventional open adnexectomy	3	1.4	0.8
Robot-assisted bilateral adnexectomy	1	0.5	0.5
Total	213	100.0	

Out of the 33 patients included in the study, 33 did not undergo cytoreductive surgery. After histological verification and chemotherapy, some patients were deemed unsuitable for interval surgery due to worsening general conditions and lack of response to chemotherapy.

Among the patients who had surgery, the most common procedure (53.1%) was total abdominal hysterectomy with bilateral salpingo-oophorectomy, followed by diagnostic laparoscopy with subsequent laparotomy (14.6%) (Table 2).

Table 2. Frequency distribution of patients according to the type of operation.

Type of diagnostic intervention	n	%	Sp
Not done	33	15.5	2.5
Total abdominal hysterectomy with bilateral salpingo-oophorectomy	113	53.1	3.4
Diagnostic laparoscopy followed by total abdominal hysterectomy with bilateral salpingo-oophorectomy	31	14.6	2.4
Robot-assisted total hysterectomy with bilateral salpingo-oophorectomy	25	11.7	2.2
Total laparoscopic hysterectomy with bilateral salpingo-oophorectomy	8	3.8	1.3
Fertility-sparing open adnexectomy	2	0.9	0.7
Total hysterectomy with previously removed adnexa.	1	0.5	0.5
Total	213	100.0	

Interval surgery was performed on 31 (14.6%) of the patients. Out of the patients who underwent interval surgery, diagnostic intervention using a minimally invasive approach was conducted on 27 (87.1%) patients (Table 3). Moreover, 21 (67.7%) patients who had interval surgery also underwent surgery using a minimally invasive approach (Table 4).

The data indicates that the most common diagnostic intervention among patients with interval surgery was diagnostic laparoscopy with biopsy (45.2%). The most frequent operation was robot-assisted total hysterectomy with bilateral salpingo-oophorectomy (64.5%). Additionally, 3 (27.3%) of the patients who underwent diagnostic intervention through open surgery also had surgery using a minimally invasive approach.

Table 3. Frequency distribution of patients with interval surgery and diagnostic intervention by minimally invasive approach.

Type of diagnostic intervention	n	%	Sp
Diagnostic laparoscopy with biopsy	14	45.2	8.9
Unilateral laparoscopic adnexectomy	9	29.0	8.2
Bilateral laparoscopic adnexectomy	4	12.9	6.0
Robot-assisted bilateral adnexectomy	0	0.0	0.0
Other	4	12.9	6.0
Total	4	12.9	

Table 4. Frequency distribution of patients with interval surgery in which the operation was performed through a minimally invasive approach.

Type of diagnostic intervention	n	%	Sp
Total laparoscopic hysterectomy with bilateral salpingo-oophorectomy	1	3.2	3.2
Robot-assisted total hysterectomy with bilateral salpingo-oophorectomy	20	645	8.6
Other	10	32.3	8.4
Total	31	100.0	

The study revealed significantly higher proportions of interval surgery in stages IIIC and IVA. From the entire sample, 14 (6.5%) patients underwent second-look laparoscopy, 12 (5.6%) with a positive result for tumour cells, and 2 (0.9%) with a negative result (Table 5).

Table 5. Frequency distribution of patients about second-look laparoscopy.

Second-look laparoscopy	n	%	Sp
Not done	199	93.4	1.7
Positive for tumour cells	12	5.6	1.6
Negative for tumour cells	2	0.9	0.7
Total	213	100.0	

Discussion

Ovarian carcinoma predominantly manifests in postmenopausal women. In an extensive analysis of ovarian cancer, Barber (1986) remarked that “although the ovary is too old to function, it never gets too old to form cancer”. In our group of patients, 45 (21%) were over 70 years old. Unlike breast carcinoma, where young age was linked to a worse prognosis, in ovarian carcinoma patients, young age was associated with a better prognosis. Besides its correlation with factors like FIGO stage and grading, numerous studies have indicated that being young is an independent predictor of better survival (Chan et al. 2006). Various studies attribute this to different reasons, with the most frequently cited being the increased microvascular density, which could be linked to a more favourable response to paclitaxel/platinum-based chemotherapy (Chan et al. 2006). In our study, the age group with the largest relative share (29.6%) was 60–69 years, followed by 50–59 years with 25.4%. Among all the patients in the study, 51 (23.9%) were of reproductive age (15–49 years). Two fertility preservation operations were performed, both using conventional open surgery.

The role of minimally invasive surgery in the treatment of ovarian carcinoma can be broadly summarised as:

1. Staging and treatment of early ovarian carcinoma
2. Histological verification and assessment of resectability
3. Second-look laparoscopy
4. Interval surgery

The most common ovarian tumours, especially in reproductive age, are benign. The European Society of Gynaecological Oncology, the International Society of Ultrasound in Obstetrics and Gynecology, the International Ovarian Tumour Analysis group, and the European Society for Gynaecological Endoscopy collaboratively established clinically significant and evidence-based statements regarding the diagnosis of ovarian tumours, including imaging methods, biomarkers, and prediction models (Timmerman et al. 2021). However, none of the mentioned models has offered 100% accuracy in sensitivity and specificity. Laparoscopy has been utilised to evaluate these patients and enhance the precision of diagnosis (Childers et al. 1996). The implementation of a laparoscopic approach in the management of adnexal masses serves to mitigate the occurrence of unnecessary laparotomy overtreatment.

The safety of using a laparoscopic approach as an alternative to midline laparotomy for early-stage ovarian cancer patients is a topic of debate. However, due to the significant absence of prospective trials and the increased risk of capsule rupture, midline laparotomy is still considered the standard procedure (Ledermann et al. 2013). In recent years, the number of early-stage ovarian cancer patients undergoing minimally invasive surgery has been increasing. However, there is limited survival data available regarding the various surgical approaches. The primary oncological concerns revolve around the potential for tumour spillage and port-site metastasis. Some risk factors are associated with an increased risk of intraoperative capsule rupture, so this risk requires a strict selection of patients suitable for minimally invasive surgical treatment. According to the LOChneSS Study, which included 151 patients with early ovarian carcinoma, larger tumour diameter ($p < .001$), a higher body mass index ($p = .032$), ultrasound characteristics ($p = .029$), and adhesions to large bowel (14% vs 2.0%; $p = .003$), uterus (44% vs 6.9%; $p <.001$), contralateral ovary (8.0% vs 0%; $p = .004$), ovarian fossa (64% vs 14.9%; $p <.001$), and pouch of Douglas peritoneum (32% vs 4.0%; $p < .001$) were linked to an increased rupture rate. A difference in disease-free survival (DFS) was observed between the rupture group and the no-rupture group (5-year DFS, 74.9% vs 94.4%; $p = .011$), while the overall survival rates were similar (5-year overall survival, 91.2% vs 97.9%; $p = .089$) (Ghirardi et al. 2022).

Patients diagnosed with localised tumours have a significantly higher chance of surviving for five years compared to those with advanced-stage disease, even though these tumours represent only 20 to 25% of all ovarian cancer cases (Siegel et al. 2014; Fagotti et al. 2016). In this study, 54 out of the total patients (25.4%) were diagnosed with early-stage ovarian carcinoma (Stage I and II FIGO). Of these patients, 13 (24.1%) underwent minimally invasive surgery as the primary treatment or for diagnostic purposes. The breakdown of these procedures is as follows: 3 patients underwent total laparoscopic hysterectomy with bilateral salpingo-oophorectomy, five patients had robot-assisted total

hysterectomy with bilateral salpingo-oophorectomy, and five patients underwent diagnostic laparoscopy followed by abdominal hysterectomy with adnexes. Additionally, 39 patients underwent total abdominal hysterectomy with bilateral salpingo-oophorectomy. The main reason for performing laparotomy was the presence of a large tumour diameter that poses a risk of capsule rupture.

According to the recommendations of the ESGO-ESMO-ESP consensus conference on ovarian cancer, minimally invasive surgery that avoids tumour rupture is considered an appropriate approach for women who want to preserve their fertility (Ledermann et al. 2024). In our study, only two patients underwent fertility-sparing surgery, and both of them had a unilateral conventional open adnexectomy.

Histological verification and assessment of resectability are perhaps the most frequently used minimally invasive approaches in treating ovarian carcinoma. Residual tumour after primary surgery is the most crucial prognostic factor in advanced ovarian cancer patients. The acceptance of using laparoscopy as a reliable method for evaluating disease severity and forecasting the feasibility of disease resection is now widely acknowledged and endorsed by both ESMO-ESGO (Ledermann et al. 2024) and the National Comprehensive Cancer Network (NCCN) guidelines (Armstrong et al. 2021; Ghirardi et al. 2023). Utilising diagnostic laparoscopy for decision-making significantly decreased the incidence of unnecessary laparotomies and complications. Rutten et al. (2014) showed that adding diagnostic laparoscopic assessment to the standard of care significantly reduced the rate of unnecessary laparotomies (10% vs 39%, $p < 0.001$) (Lee et al. 2023). In the laparoscopy group, 57% of the patients undergoing primary debulking surgery achieved complete cytoreduction (Rutten et al. 2014; Lee et al. 2023). Different scoring systems are used to predict unresectability. One of the most commonly used is the Peritoneal Cancer Index, initially proposed by Jacquet and Sugarbaker (1996). This score standardises the quantification of peritoneal spread in gastrointestinal cancer (Pinto et al. 2023). To objectively assess tumour volume Fagotti et al. (2006) introduced a laparoscopic predictive index to evaluate the likelihood of residual disease exceeding 1 cm post cytoreductive surgery. In 2015, the scoring system was updated to meet the new trends that required R0 resection of the tumour. As a result of this update, the rate of unnecessary laparotomies decreased from 40.5% to 33.2% (Petrillo et al. 2015). The importance of diagnostic laparoscopy in treating ovarian carcinoma has grown, particularly since the publication of the MRC OV05/EORTC collaborative trial (Rustin et al. 2010). Avoidance of unnecessary laparotomies and their associated complications and starting chemotherapy more quickly in patients who are not suitable for primary cytoreductive surgery have been proven to be highly advantageous.

Of the 213 patients in our study, 166 were found to have advanced-stage ovarian carcinoma. Initially, 84 of these patients underwent a diagnostic laparoscopy. Of these, 31 were deemed suitable for surgical treatment and consequently underwent total abdominal hysterectomy with bilateral salpingo-oophorectomy. The remaining 53 patients were considered inoperable, confirmed by histological verification, and were referred to chemotherapy. In this manner, we avoided 53 unnecessary laparotomies, significantly reducing hospital stays, the risk of complications, and hospital costs. Additionally, this approach provided sufficient material for histological and sometimes genetic testing and faster access to chemotherapy for the patient. In six additional patients, due

to insufficient pre-operative assessment of disease spread and the lack of laparoscopy in the diagnostic process, six unnecessary laparotomies were performed. These included three exploratory laparotomies with biopsy and three unilateral conventional open adnexectomies.

Secondary surgical reassessments after the initial debulking surgery and chemotherapy in individuals with advanced ovarian cancer have been conducted for many years. Currently, the purpose of the second-look assessment is to identify patients with microscopic residual ovarian cancer after finishing the initial chemotherapy and also to identify those patients with more extensive disease who may benefit from additional cytoreductive surgery (Husain et al. 2001). Indications for second-look laparoscopy include elevated CA125 and inconclusive imaging findings. Fourteen of the included patients underwent second-look laparoscopy, revealing tumour persistence or recurrence in 12 cases. However, none of the cases were eligible for secondary cytoreduction.

Prospective trials have shown that administering three cycles of platinum-based neoadjuvant chemotherapy first, followed by interval cytoreductive surgery and completion chemotherapy, was just as effective as conducting primary cytoreductive surgery followed by chemotherapy in patients with advanced bulky stage IIIC or IV disease. This applies to cases where complete resection during the initial surgery is unlikely due to extensive disease or when extensive surgery is not tolerable due to frailty or other significant comorbidities (Ledermann et al. 2013). The European Organization for Research and Treatment of Cancer (EORTC) published the earliest study in 2010. Other phase III studies that compare primary debulking surgery and neoadjuvant chemotherapy include CHORUS, JCOG0602, and SCORPION. According to EORTC 55971 and CHORUS trials, "neoadjuvant chemotherapy has been associated with better clinical outcome than primary debulking surgery in International Federation of Gynecology and Obstetrics (FIGO) stage IV patients, whereas patients with an initial abdominal disease of <5 cm treated with primary debulking surgery had an increased survival rate when compared with those who underwent neoadjuvant chemotherapy" (Vergote et al. 2018; Fagotti et al. 2020). An essential benefit of neoadjuvant chemotherapy is a reduction in surgical morbidity. In the Chorus trial, postoperative deaths occurred in 6% of those who underwent primary surgery versus 1% of those who received neoadjuvant chemotherapy (Kehoe et al. 2015; Ackroyd et al. 2018).

Cytoreductive surgery has traditionally been performed using laparotomy. Several published studies have demonstrated that minimally invasive interval debulking surgery is a viable and safe approach for patients who have achieved a clinically complete response after neoadjuvant chemotherapy. The median progression-free and overall survival outcomes reported in the MISSION Trial provide reassurance about the safety of this approach (Fagotti et al. 2019). Following its approval by the Food and Drug Administration for gynecologic procedures in 2005, the da Vinci Surgical System was soon adopted in uterine cancer treatment. Similar to laparoscopy, it has led to decreased operative blood loss, fewer postoperative complications, and expedited recovery (Abitbol et al. 2019). There are several advantages of robotic surgery compared to laparotomy, and in some respects also compared to laparoscopic surgery.

In our study, interval surgery was performed on 31 (14.6%) patients. The study showed statistically significantly more significant relative proportions

of applied interval surgery in stages IIIC and IVA. The most common procedure is robot-assisted total hysterectomy with bilateral salpingo-oophorectomy (64.5%). We believe that robotic surgery is a safe and feasible approach for all patients who respond well to chemotherapy.

The use of minimally invasive surgery in the primary debulking of advanced ovarian cancer and the treatment of recurrences is a topic of debate.

In advanced EOC, surgery aims to achieve a complete or optimal cytoreduction, defined as total macroscopic tumour clearance with no visible residual disease, since this has been shown to increase overall survival and progression-free survival significantly (Du Bois et al. 2009). Regarding the use of minimally invasive surgery as a treatment option for advanced-stage ovarian cancer, only a few retrospective, non-randomised studies have been published. The need for accurate assessment of residual disease and performing major surgical procedures like bowel resection and upper abdominal surgery limits the use of minimally invasive approaches (Scarpelli et al. 2022).

Even with optimal surgery and appropriate initial chemotherapy, 80% of patients with EOC will experience a recurrence at different times (Pignata et al. 2017). Surgical options for recurrent ovarian cancer involve secondary cytoreductive surgery and palliative surgical interventions. The results of the randomised DESKTOP-III trial have shown that patients undergoing secondary cytoreductive surgery followed by chemotherapy have better overall survival than those receiving chemotherapy alone, mainly when complete cytoreduction is achieved (Harter et al. 2021; Conte et al. 2023). Patients with ovarian cancer experiencing their first relapse more than six months after completing first-line platinum-based chemotherapy should be evaluated for secondary cytoreductive surgery (Ledermann et al. 2013). There are no established criteria for determining which patients are suitable for minimally invasive surgery. However, it is feasible in selected patients with oligometastatic platinum-sensitive recurrent epithelial ovarian cancer (Conte et al. 2023).

In our study, due to conflicting results and the limited number of randomised trials, no patients with advanced ovarian carcinoma underwent primary cytoreductive surgery with a minimally invasive approach. Similarly, the minimally invasive approach was not used in the treatment of recurrent ovarian cancer for the same reasons.

Conclusion

In conclusion, from the studied group of 213 patients, the operation in 92 was started through a minimally invasive approach. Of these, 39 were considered suitable for surgical treatment: 8 of them underwent minimally invasive surgery, and 31 proceeded to laparotomy. The remaining 53 patients were deemed inoperable and were referred to chemotherapy after histological verification. Interval surgery was performed on 31. In 20 of the cases, robot-assisted total hysterectomy with bilateral salpingo-oophorectomy was performed. Due to a lack of response to chemotherapy or poor performance status, the remaining 22 patients were not suitable for surgical treatment, and such treatment was not performed. The obtained results show that minimally invasive approaches are widely used in the diagnosis and treatment of ovarian carcinoma. Creating an algorithm that incorporates multiple diagnostic methods, such as diagnostic

laparoscopy, would notably decrease the need for unnecessary laparotomies. The increasing adoption of interval surgery will expand another application of minimally invasive surgery - robot-assisted interval surgery after neoadjuvant chemotherapy.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statements

The authors declared that no clinical trials were used in the present study.
The authors declared that no experiments on humans or human tissues were performed for the present study.
Informed consent from the humans, donors or donors' representatives: University Hospital St. Marina–Pleven.
The authors declared that no experiments on animals were performed for the present study.
The authors declared that no commercially available immortalised human and animal cell lines were used in the present study.

Funding

No funding was reported.

Author contributions

Data curation: DGD, VR. Formal analysis: DGD, TKS. Investigation: TKS, ZG. Methodology: ZG. Software: DGD. Supervision: ST, TT. Validation: VR, ZG. Visualization: VR. Writing - original draft: TKS. Writing - review and editing: ST, TT.

Author ORCIDs

Tihomir Totev https://orcid.org/0000-0002-4381-3082
Dimitar Dimitrov https://orcid.org/0009-0008-5992-5530
Valeria Racheva https://orcid.org/0000-0001-7777-7713

Data availability

All of the data that support the findings of this study are available in the main text.

References

Abitbol J, Gotlieb W, Zeng Z, Ramanakumar A, Kessous R, Kogan L, Pare-Miron V, Rombaldi M, Salvador S, Kucukyazici B, Brin S, How J, Lau S (2019) Incorporating robotic surgery into the management of ovarian cancer after neoadjuvant chemotherapy. International Journal of Gynecologic Cancer 29: 1341–1347. https://doi.org/10.1136/ijgc-2019-000413

Ackroyd SA, Thomas S, Angel C, Moore R, Meacham PJ, DuBeshter B (2018) Interval robotic cytoreduction following neoadjuvant chemotherapy in advanced ovarian cancer. Journal of Robotic Surgery 12: 245–250. https://doi.org/10.1007/s11701-017-0720-2

Armstrong DK, Alvarez RD, Bakkum-Gamez JN, Barroilhet L, Behbakht K, Berchuck A, Chen LM, Cristea M, DeRosa M, Eisenhauer EL, Gershenson DM, Gray HJ, Grisham R,

Hakam A, Jain A, Karam A, Konecny GE, Leath CA, Liu J, Mahdi H, Martin L, Matei D, McHale M, McLean K, Miller DS, O'Malley DM, Percac-Lima S, Ratner E, Remmenga SW, Vargas R, Werner TL, Zsiros E, Burns JL, Engh AM (2021) Ovarian Cancer, Version 2.2020, NCCN Clinical Practice Guidelines in Oncology. Journal of the National Comprehensive Cancer Network 19: 191–226. https://doi.org/10.6004/jnccn.2021.0007

Barber HRK (1986) Ovarian Cancer. CA: A Cancer Journal for Clinicians 36: 149–184. https://doi.org/10.3322/canjclin.36.3.149

Boussios S, Mikropoulos C, Samartzis E, Karihtala P, Moschetta M, Sheriff M, Karathanasi A, Sadauskaite A, Rassy E, Pavlidis N (2020) Wise Management of Ovarian Cancer: On the Cutting Edge. Journal of Personalized Medicine 10: 41. https://doi.org/10.3390/jpm10020041

Chan JK, Urban R, Cheung MK, Osann K, Husain A, Teng NN, Kapp DS, Berek JS, Leiserowitz GS (2006) Ovarian cancer in younger vs older women: a population-based analysis. British Journal of Cancer 95: 1314–1320. https://doi.org/10.1038/sj.bjc.6603457

Childers JM, Nasseri A, Surwit EA (1996) Laparoscopic management of suspicious adnexal masses. American Journal of Obstetrics and Gynecology 175: 1451–1459. https://doi.org/10.1016/S0002-9378(96)70089-3

Chirasophon S, Manchana T, Teerapakpinyo C (2017) High-risk epithelial ovarian cancer patients for hereditary ovarian cancer. Journal of Obstetrics and Gynaecology Research 43: 929–934. https://doi.org/10.1111/jog.13287

Conte C, Marchetti C, Loverro M, Giudice MT, Rosati A, Gallotta V, Scambia G, Fagotti A (2023) Role of minimally invasive secondary cytoreduction in patients with recurrent ovarian cancer. International Journal of Gynecologic Cancer 33: 137–144. https://doi.org/10.1136/ijgc-2022-003904

Du Bois A, Reuss A, Pujade-Lauraine E, Harter P, Ray-Coquard I, Pfisterer J (2009) Role of surgical outcome as prognostic factor in advanced epithelial ovarian cancer: A combined exploratory analysis of 3 prospectively randomised phase 3 multicenter trials: By the Arbeitsgemeinschaft Gynaekologische Onkologie Studiengruppe Ovarialkarzinom (AGO-OVAR) and the Groupe d'Investigateurs Nationaux Pour les Etudes des Cancers de l'Ovaire (GINECO). Cancer 115: 1234–1244. https://doi.org/10.1002/cncr.24149

Fagotti A, Ferrandina G, Fanfani F, Ercoli A, Lorusso D, Rossi M, Scambia G (2006) A laparoscopy-based score to predict surgical outcome in patients with advanced ovarian carcinoma: A pilot study. Annals of Surgical Oncology 13: 1156–1161. https://doi.org/10.1245/ASO.2006.08.021

Fagotti A, Perelli F, Pedone L, Scambia G (2016) Current recommendations for minimally invasive surgical staging in ovarian cancer. Current Treatment Options in Oncology 17: 3. https://doi.org/10.1007/s11864-015-0379-8

Fagotti A, Gueli Alletti S, Corrado G, Cola E, Vizza E, Vieira M, Andrade CE, Tsunoda A, Favero G, Zapardiel I, Pasciuto T, Scambia G (2019) The INTERNATIONAL MISSION study: minimally invasive surgery in ovarian neoplasms after neoadjuvant chemotherapy. International Journal of Gynecologic Cancer 29: 5–9. https://doi.org/10.1136/ijgc-2018-000012

Fagotti A, Ferrandina MG, Vizzielli G, Pasciuto T, Fanfani F, Gallotta V, Margariti PA, Chiantera V, Costantini B, Gueli Alletti S, Cosentino F, Scambia G (2020) Randomised trial of primary debulking surgery versus neoadjuvant chemotherapy for advanced epithelial ovarian cancer (SCORPION-NCT01461850). International Journal of Gynecologic Cancer 30: 1657–1664. https://doi.org/10.1136/ijgc-2020-001640

Gaona-Luviano P, Medina-Gaona LA, Magana-Perez K (2020) Epidemiology of ovarian cancer. Chinese Clinical Oncology 9: 47–47. https://doi.org/10.21037/cco-20-34

Ghirardi V, De Felice F, Rosati A, Ergasti R, Gueli Alletti S, Mascilini F, Scambia G, Fagotti A (2022) A laparoscopic adjusted model able to predict the risk of intraoperative capsule rupture in early-stage ovarian cancer: Laparoscopic Ovarian Cancer Spillage Score (LOChneSS Study). Journal of Minimally Invasive Gynecology 29: 961–967. https://doi.org/10.1016/j.jmig.2022.04.014

Ghirardi V, Fagotti A, Ansaloni L, Valle M, Roviello F, Sorrentino L, Accarpio F, Baiocchi G, Piccini L, De Simone M, Coccolini F, Visaloco M, Bacchetti S, Scambia G, Marrelli D (2023) Diagnostic and therapeutic pathway of advanced ovarian cancer with peritoneal metastases. Cancers 15: 407. https://doi.org/10.3390/cancers15020407

Harter P, Sehouli J, Vergote I, Ferron G, Reuss A, Meier W, Greggi S, Mosgaard BJ, Selle F, Guyon F, Pomel C, Lecuru F, Zang R, Avall-Lundqvist E, Kim J-W, Ponce J, Raspagliesi F, Kristensen G, Classe J-M, Hillemanns P, Jensen P, Hasenburg A, Ghaem-Maghami S, Mirza MR, Lund B, Reinthaller A, Santaballa A, Olaitan A, Hilpert F, Du Bois A (2021) Randomised trial of cytoreductive surgery for relapsed ovarian cancer. New England Journal of Medicine 385: 2123–2131. https://doi.org/10.1056/NEJMoa2103294

Husain A, Chi DS, Prasad M, Abu-Rustum N, Barakat RR, Brown CL, Poynor EA, Hoskins WJ, Curtin JP (2001) The role of laparoscopy in second-look evaluations for ovarian cancer. Gynecologic Oncology 80: 44–47. https://doi.org/10.1006/gyno.2000.6036

Jacquet P, Sugarbaker PH (1996) Clinical research methodologies in diagnosis and staging of patients with peritoneal carcinomatosis. Peritoneal Carcinomatosis: Principles of Management. Cancer Treatment and Research 82: 359–374. https://doi.org/10.1007/978-1-4613-1247-5_23

Kehoe S, Hook J, Nankivell M, Jayson GC, Kitchener H, Lopes T, Luesley D, Perren T, Bannoo S, Mascarenhas M, Dobbs S, Essapen S, Twigg J, Herod J, McCluggage G, Parmar M, Swart A-M (2015) Primary chemotherapy versus primary surgery for newly diagnosed advanced ovarian cancer (CHORUS): an open-label, randomised, controlled, non-inferiority trial. The Lancet 386: 249–257. https://doi.org/10.1016/S0140-6736(14)62223-6

Knisely A, Gamble CR, St. Clair CM, Hou JY, Khoury-Collado F, Gockley AA, Wright JD, Melamed A (2021) The role of minimally invasive surgery in the care of women with ovarian cancer: A systematic review and meta-analysis. Journal of Minimally Invasive Gynecology 28: 537–543. https://doi.org/10.1016/j.jmig.2020.11.007

Ledermann JA, Raja FA, Fotopoulou C, Gonzalez-Martin A, Colombo N, Sessa C (2013) Newly diagnosed and relapsed epithelial ovarian carcinoma: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Annals of Oncology 24: vi24–vi32. https://doi.org/10.1093/annonc/mdt333

Ledermann JA, Matias-Guiu X, Amant F, Concin N, Davidson B, Fotopoulou C, Gonzalez-Martin A, Gourley C, Leary A, Lorusso D, Banerjee S, Chiva L, Cibula D, Colombo N, Croce S, Eriksson AG, Falandry C, Fischerova D, Harter P, Joly F, Lazaro C, Lok C, Mahner S, Marme F, Marth C, McCluggage WG, McNeish IA, Morice P, Nicum S, Oaknin A, Perez-Fidalgo JA, Pignata S, Ramirez PT, Ray-Coquard I, Romero I, Scambia G, Sehouli J, Shapira-Frommer R, Sundar S, Tan DSP, Taskiran C, Van Driel WJ, Vergote I, Planchamp F, Sessa C, Fagotti A (2024) ESGO-ESMO-ESP consensus conference recommendations on ovarian cancer: pathology and molecular biology and early, advanced and recurrent disease. Annals of Oncology 35: 248–266. https://doi.org/10.1016/j.annonc.2023.11.015

Lee YJ, Chung YS, Lee J-Y, Nam EJ, Kim SW, Kim YT, Kim S (2023) Role of diagnostic laparoscopy in deciding primary treatment in advanced-stage ovarian cancer. Journal of Gynecologic Oncology 34: e17. https://doi.org/10.3802/jgo.2023.34.e17

Menon U, Gentry-Maharaj A, Burnell M, Singh N, Ryan A, Karpinskyj C, Carlino G, Taylor J, Massingham SK, Raikou M, Kalsi JK, Woolas R, Manchanda R, Arora R, Casey L, Dawnay A, Dobbs S, Leeson S, Mould T, Seif MW, Sharma A, Williamson K, Liu Y, Fallowfield L, McGuire AJ, Campbell S, Skates SJ, Jacobs IJ, Parmar M (2021) Ovarian cancer population screening and mortality after long-term follow-up in the UK Collaborative Trial of Ovarian Cancer Screening (UKCTOCS): a randomised controlled trial. The Lancet 397: 2182–2193. https://doi.org/10.1016/S0140-6736(21)00731-5

Momenimovahed Z, Tiznobaik A, Taheri S, Salehiniya H (2019) Ovarian cancer in the world: epidemiology and risk factors. International Journal of Women's Health 11: 287–299. https://doi.org/10.2147/IJWH.S197604

Nezhat FR, Pejovic T, Finger TN, Khalil SS (2013) Role of minimally invasive surgery in ovarian cancer. Journal of Minimally Invasive Gynecology 20: 754–765. https://doi.org/10.1016/j.jmig.2013.04.027

Norquist BM, Harrell MI, Brady MF, Walsh T, Lee MK, Gulsuner S, Bernards SS, Casadei S, Yi Q, Burger RA, Chan JK, Davidson SA, Mannel RS, DiSilvestro PA, Lankes HA, Ramirez NC, King MC, Swisher EM, Birrer MJ (2016) Inherited mutations in women with ovarian carcinoma. JAMA Oncology 2: 482–490. https://doi.org/10.1001/jamaoncol.2015.5495

Petrillo M, Vizzielli G, Fanfani F, Gallotta V, Cosentino F, Chiantera V, Legge F, Carbone V, Scambia G, Fagotti A (2015) Definition of a dynamic laparoscopic model for the prediction of incomplete cytoreduction in advanced epithelial ovarian cancer: Proof of a concept. Gynecologic Oncology 139: 5–9. https://doi.org/10.1016/j.ygyno.2015.07.095

Pignata S, Cecere SC, Du Bois A, Harter P, Heitz F (2017) Treatment of recurrent ovarian cancer. Annals of Oncology 28: 51–56. https://doi.org/10.1093/annonc/mdx441

Pinto P, Burgetova A, Cibula D, Haldorsen IS, Indrielle-Kelly T, Fischerova D (2023) Prediction of surgical outcome in advanced ovarian cancer by imaging and laparoscopy: A narrative review. Cancers 15: 1904. https://doi.org/10.3390/cancers15061904

Rustin GJ, van der Burg ME, Griffin CL, Guthrie D, Lamont A, Jayson GC, Kristensen G, Mediola C, Coens C, Qian W, Parmar MK, Swart AM (2010) Early versus delayed treatment of relapsed ovarian cancer (MRC OV05/EORTC 55955): a randomised trial. The Lancet 376: 1155–1163. https://doi.org/10.1016/S0140-6736(10)61268-8

Rutten MJ, Leeflang MM, Kenter GG, Mol BWJ, Buist M (2014) Laparoscopy for diagnosing resectability of disease in patients with advanced ovarian cancer. Cochrane Database of Systematic Reviews 2: 1465–1858. https://doi.org/10.1002/14651858.CD009786.pub2

Scarpelli E, Armano G, Monfardini L, Valenti A, Barresi G, De Finis A, Rotondella I, Scebba D, Butera D (2022) Minimally invasive surgery in gynecological cancers: update and systematic review. Clinical and Experimental Obstetrics & Gynecology 49: 88. https://doi.org/10.31083/j.ceog4904088

Shah S, Cheung A, Kutka M, Sheriff M, Boussios S (2022) Epithelial ovarian cancer: Providing evidence of predisposition genes. International Journal of Environmental Research and Public Health 19: 8113. https://doi.org/10.3390/ijerph19138113

Siegel R, Ma J, Zou Z, Jemal A (2014) Cancer statistics, 2014. CA: A Cancer Journal for Clinicians 64: 9–29. https://doi.org/10.3322/caac.21208

Timmerman D, Planchamp F, Bourne T, Landolfo C, Du Bois A, Chiva L, Cibula D, Concin N, Fischerova D, Froyman W, Gallardo Madueno G, Lemley B, Loft A, Mereu L, Morice P, Querleu D, Testa AC, Vergote I, Vandecaveye V, Scambia G, Fotopoulou C (2021) ESGO/ISUOG/IOTA/ESGE Consensus Statement on pre-operative diagnosis of

ovarian tumors. International Journal of Gynecologic Cancer 31: 961–982. https://doi.org/10.1136/ijgc-2021-002565

Vergote I, Coens C, Nankivell M, Kristensen GB, Parmar MKB, Ehlen T, Jayson GC, Johnson N, Swart AM, Verheijen R, McCluggage WG, Perren T, Panici PB, Kenter G, Casado A, Mendiola C, Stuart G, Reed NS, Kehoe S (2018) Neoadjuvant chemotherapy versus debulking surgery in advanced tubo-ovarian cancers: pooled analysis of individual patient data from the EORTC 55971 and CHORUS trials. The Lancet Oncology 19: 1680–1687. https://doi.org/10.1016/S1470-2045(18)30566-7