Minimally invasive versus open pelvic exenteration in gynecological malignancies: a propensity-matched survival analysis

Nicolò Bizzarri ,[1] Vito Chiantera,[2] Matteo Loverro ,[1] Giulio Sozzi ,[2] Emanuele Perrone,[1] Salvatore Gueli Alletti,[1] Barbara Costantini,[1] Valerio Gallotta,[1] Lucia Tortorella,[1] Anna Fagotti ,[1] Francesco Fanfani ,[1] Alfredo Ercoli,[3] Giovanni Scambia ,[1] Giuseppe Vizzielli[4,5]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/ijgc-2022-003954).

For numbered affiliations see end of article.

Correspondence to
Dr Nicolò Bizzarri, UOC Ginecologia Oncologica, Dipartimento per la salute della Donna e del Bambino e della Salute Pubblica, Policlinico Agostino Gemelli IRCCS, Rome 00168, Italy; nicolo.bizzarri@yahoo.com

For 'Presented at statement' see end of article.

Received 30 August 2022
Accepted 19 December 2022
Published Online First 2 January 2023

To cite: Bizzarri N, Chiantera V, Loverro M, *et al. Int J Gynecol Cancer* 2023;**33**:190–197.

ABSTRACT

Objective The primary endpoint of this study was to compare the disease-free survival of patients undergoing open versus minimally invasive pelvic exenteration. The secondary endpoints were cancer-specific survival and peri-operative morbidity.

Methods A multi-center, retrospective, observational cohort study was undertaken. Patients undergoing curative and palliative anterior or total pelvic exenteration for gynecological cancer by a minimally invasive approach and an open approach between June 2010 and May 2021 were included. Patients with distant metastases were excluded. A 1:2 propensity match analysis between patients undergoing minimally invasive and open pelvic exenteration was performed to equalized baseline characteristics.

Results After propensity match analysis a total of 117 patients were included, 78 (66.7%) and 39 (33.3%) in the open and minimally invasive group, respectively. No significant difference in intra-operative (23.4% vs 10.3%, p=0.13) and major post-operative complications (24.4% vs 17.9%, p=0.49) was evident between the open and minimally invasive approach. Patients undergoing open pelvic exenteration received higher rates of intra-operative transfusions (41.0% vs 17.9%, p=0.013). Median disease-free survival was 17.0 months for both the open and minimally invasive groups (p=0.63). Median cancer-specific survival was 30.0 months and 26.0 months in the open and minimally invasive groups, respectively (p=0.80). Positivity of surgical margins at final histology was the only significant factor influencing the risk of recurrence (hazard ratio (HR) 2.38, 95% CI 1.31 to 4.31) (p=0.004), while tumor diameter ≥50 mm at the time of pelvic exenteration was the only significant factor influencing the risk of death (HR 1.83, 95% CI 1.08 to 3.11) (p=0.025).

Conclusion In this retrospective study no survival difference was evident when minimally invasive pelvic exenteration was compared with open pelvic exenteration in patients with gynecological cancer. There was no difference in peri-operative complications, but a higher intra-operative transfusion rate was seen in the open group.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Minimally invasive pelvic exenteration for gynecological malignancies is feasible and provides improved peri-operative outcomes compared with the open approach. However, the oncological outcomes of minimally invasive pelvic exenteration are still poorly described.

WHAT THIS STUDY ADDS

⇒ No disease-free or cancer-specific survival difference was evident between minimally invasive and open pelvic exenterations based on these retrospective data. Patients treated with minimally invasive pelvic exenteration received fewer intra-operative transfusions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ A minimally invasive approach might be considered in highly selected patients treated in referral centers and possibly included in the setting of prospective trials.

INTRODUCTION

Pelvic exenteration is a major radical operation which aims to remove the uterus/vagina, adnexae, bladder and/or rectosigmoid colon, and it represents a salvage procedure in recurrent gynecologic cancers previously treated with radiotherapy.[1 2] In selected patients in whom this surgical procedure is performed with curative intent, overall survival ranges from 20% to 73% at 5 years.[2–6] Since its first description, the surgical approach to pelvic exenteration has traditionally been open surgery.[7 8] Nevertheless, recently, different series have been published, reporting favorable peri-operative outcomes when patients underwent minimally invasive pelvic exenteration.[9 10]

A recent study reported that minimally invasive pelvic exenteration was associated with a reduced incidence of high-risk complications such as sepsis and thromboembolism compared with the open approach. Furthermore, the minimally invasive group had a shorter length of stay and lower total charge compared with the open surgery group.[11] However, the oncological safety of minimally invasive pelvic exenteration has only been analyzed in a few case

reports or small case series with limited follow-up and in most cases no comparison with an open approach group.[10 12–15]

The primary endpoint of the present study was to compare the disease-free survival in patients undergoing open versus minimally invasive pelvic exenteration. Secondary endpoints were comparison of cancer-specific survival and peri-operative morbidity between the two groups.

METHODS

This is a two-center, retrospective, observational cohort study approved by the Policlinico Agostino Gemelli IRCCS Ethical Committee (number 0011322/21 on March 25, 2021).

Consecutive patients undergoing anterior or total pelvic exenteration with curative or palliative intent for recurrent/persistent gynecological cancer between June 2010 and May 2021 at Fondazione Policlinico Agostino Gemelli IRCCS, Rome, Italy and ARNAS Ospedali Civico Di Cristina Benfratelli, University of Palermo, Italy were included. Patients with newly diagnosed locally advanced gynecological cancers with a vesico-vaginal or ureter-vaginal fistula were also considered candidates for primary pelvic exenteration after multisciplinary tumor board discussion and patient counseling. Pelvic exenteration was defined as palliative in cases of positive para-aortic or inguino-femoral lymph nodes and aimed to improve symptoms such as incontinence secondary to fistulae, pain, and bleeding. All women underwent pre-operative imaging of the pelvis with magnetic resonance imaging and/or ultrasound in order to assess the local infiltration, while a computed tomography (CT) scan of the chest and abdomen or a positron emission tomography (PET)/CT scan was performed to exclude distant metastases. The surgery was performed by experienced gynecologic oncology surgeons in high-volume referral centers. The approach to pelvic exenteration was selected according to the surgeon's preference.

In the minimally invasive group, allocation to laparoscopy or robot was performed according to the patient's body mass index and the surgeon's preference. The decision to perform anterior versus total pelvic exenteration was taken according to disease extension on pre-operative imaging. The technique of pelvic exenteration was the same for patients undergoing the open or minimally invasive approach.[16] Patients with distant metastasis at pre-operative imaging were excluded. Surgery was attempted as removal of one single specimen with surgical margins free from tumor. Tumor diameter at the time of pelvic exenteration was measured on the histology specimen by a dedicated gynecologic oncology pathologist. Adjuvant treatment was performed according to pathologic major risk factors on the specimen (positive pelvic lymph nodes or positive surgical margins) or at the discretion of the multidisciplinary tumor board.

Statistical Analysis

A case/control comparison with a historical series of open pelvic exenteration (controls) was performed. In view of the potential allocation biases rising from the retrospective comparison between the groups (minimally invasive vs open), we performed a propensity match analysis. This aimed to reduce biases arising from different baseline covariates. A propensity score was developed through a multivariable logistic regression model between the groups. Patients undergoing minimally invasive pelvic exenteration were matched in a 1:2 ratio with patients undergoing open pelvic exenteration using a caliper width ≤0.1 SD of the estimated propensity score logit odds. The variables used to develop the propensity match analysis were site of primary disease, surgical margins at histology, tumor diameter, and histology of pelvic lymph nodes. This dimension allowed us to detect, with a power of 90%, an expected proportion of complications of 55% (control group) and 15% (case group) with one-sided α=0.01.

Standard descriptive statistics were used to evaluate the distribution of each variable. Continuous variables were reported as median and categorical variables as frequency and percentage. Comparison of each variable between the open and minimally invasive pelvic exenteration groups were performed using a t-test for continuous variables and χ^2 or Fisher's exact test for categorical variables.

Intra-operative complications were defined as any deviation from the ideal intra-operative course occurring between skin incision and skin closure[17] and were graded according to the Common Terminology Criteria for Adverse Events (CTCAE) version 5.0 classification,[18] while post-operative complications were defined as any deviation from the normal post-operative course and were classified according to the Clavien–Dindo system.[19] Intra-operative transfusions were not considered as intra-operative complications but were counted separately. Post-operative complications were divided into early (up to post-operative day 30) and late (post-operative days 31–180). Disease-free survival was defined as the interval between pelvic exenteration and diagnosis of subsequent recurrence, death, or last follow-up if no event was detected. Cancer-specific survival was calculated as the time in months from the date of the pelvic exenteration to the date of the last follow-up or death from gynecological cancer. Patients were followed up until December 2021. The survival curves were estimated with the Kaplan–Meier product-limit method.[20] The log-rank test was used to assess differences between sub-groups,[21] and significance was defined at the $p<0.05$ level. The hazard ratio (HR) and the confidence intervals (CIs) were estimated for each variable using the Cox regression model.[22] Cut-off for the tumor diameter variable was selected according to a receiver operating characteristic (ROC) curve. SPSS version 25.0 (SPSS, Chicago, Illinois, USA) and NCSS statistical software version 11.0 (NCSS Statistical Software, Kaysville, Utah, USA) were used.

RESULTS

Patient Characteristics

One hundred and fifty-four patients were included in the study period, of which 115 (74.6%) underwent open pelvic exenteration and 39 (25.4%) underwent minimally invasive pelvic exenteration. After propensity match analysis with a 1:2 ratio to eliminate potential differences in baseline characteristics, 117 patients were included, of whom 78 (66.7%) and 39 (33.3%) were in the open and minimally invasive groups, respectively (Figure 1). Of the patients undergoing the minimally invasive approach, 26 (66.7%) had laparoscopic surgery and 13 (33.3%) had robotic surgery. The characteristics of the included patients are shown in Table 1. No significant difference in patient characteristics was evident between the two groups. Most patients were diagnosed with cervical cancer (n=78,

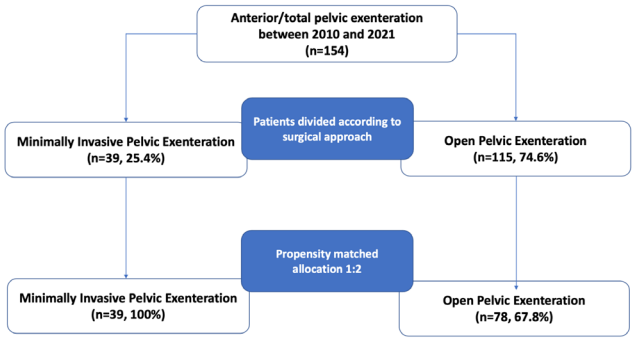

Figure 1 Inclusion process.

66.7%), underwent definitive chemoradiotherapy (n=54, 46.1%), and were treated with anterior pelvic exenteration (n=70, 59.8%). Ninety-nine (84.6%) patients had negative surgical margins at final histology, while adjuvant treatment was administered in 58 (49.6%) patients. All patients underwent incontinent ileal conduit urinary diversion (Bricker or Wallace type I). The number of laterally extended endopelvic resections performed by the open and minimally invasive approach was 21 (26.9%) and 3 (7.7%), respectively (p=0.016). Fourteen (12.0%) patients underwent palliative exenteration with no difference in distribution between the two study groups (p=0.38). The proportion of patients undergoing the minimally invasive approach significantly increased over time (from 2.6% in 2010–2013 to 51.3% in 2014–2017 and 46.2% in 2018–2021, p=0.033; see Online Supplemental Table 1).

Table 2 shows the peri-operative outcomes of both groups. Three (7.7%) patients underwent conversion from minimal access to laparotomy and they were included in the minimally invasive group. The only significant difference in intra-operative and post-operative complications was the number of patients receiving an intra-operative transfusion, which was higher in the open exenteration group (41.0% vs 17.9%, p=0.013). Online Supplemental Table 2 shows the details of intra-operative and post-operative complications. The most frequent intra-operative, early post-operative, and late post-operative complications were vascular injury (17/22, 77.3%), wound dehiscence/infection (23/105, 21.9%), and ureter stenosis (12/53, 22.6%), respectively, with no difference in the incidence of these complications between the minimally invasive and open surgery groups.

Survival Analysis

The median follow-up time of the entire population was 37 months (95% CI 23.0 to 40.0). The median disease-free survival was 17.0 months (95% CI 12.8 to 21.2) and the median cancer-specific survival was 26.0 months (95% CI 19.5 to 32.5) for the entire cohort. The median disease-free survival was 17.0 months (95% CI 11.8 to 22.1) and 17.0 months (95% CI 8.2 to 25.8) in the open and minimally invasive groups, respectively (p=0.63) (Figure 2A). The median cancer-specific survival was 30.0 months (95% CI 22.1 to 37.9) in the open group and 26.0 months (95% CI 17.8 to 32.5) in the minimally invasive group (p=0.80) (Figure 2B). No disease-free survival or cancer-specific survival difference was evident between patients operated with the laparoscopic versus the robotic approach (median disease-free survival 22 and 13 months, respectively, p=0.47; median cancer-specific survival 28 and 22 months, respectively, p=0.14) (see Online Supplemental Figure 1). No disease-free survival or cancer-specific survival difference was evident in the sub-group of patients with tumors ≥50 mm at the time of exenteration between patients operated with an open versus a minimally invasive approach (median disease-free survival 12 and 15 months, respectively, p=0.95; median cancer-specific survival 17 and 22 months, respectively, p=0.74).

Table 3 shows the univariable Cox regression analysis for the risk of recurrence and death. Positivity of surgical margins at final histology was the only significant factor influencing the risk of recurrence (HR 2.378, 95% CI 1.313 to 4.308; p=0.004). Tumor diameter ≥50 mm at the time of exenteration was the only significant factor influencing the risk of death (HR 1.833, 95% CI 1.080 to 3.111; p=0.025). No multivariable analysis was performed due to the small number of events compared with the number of variables.

DISCUSSION

Summary of Main Results

In our study there was no difference in disease-free survival or cancer-specific survival between patients undergoing minimally invasive versus open pelvic exenteration. No significant difference was found in peri-operative morbidity in our patients (apart from the higher incidence of intra-operative transfusions in the group treated with the open approach). The lack of difference in morbidity in our series may be explained by the relatively low incidence of major complications in both groups. Nevertheless, even if not significant, the minimally invasive group reported a lower incidence of peri-operative complications (Table 2).

Results in the Context of Published Literature

Different studies have previously reported the feasibility and the better peri-operative outcomes of minimally invasive pelvic exenteration.[10 11] However, few studies have reported the survival outcomes of patients undergoing the minimally invasive approach, particularly compared with the open approach.[12] A recent study by Matsuo et al showed that the minimally invasive approach was associated with a decreased incidence of sepsis and thromboembolism compared with an open approach in a retrospective population-based analysis of the National Inpatient Sample.[11] In the present series, the incidence of post-operative complications is comparable to other series of pelvic exenteration for gynecologic malignancies.[23] No difference in post-operative morbidity was noted between the open and minimal access approach, but a trend towards a higher incidence of wound dehiscence/infection, blood transfusion, and bowel obstruction in the laparotomy group has to be mentioned.

Our survival rate is comparable to those reported in other pelvic exenteration series.[6 9 12] In particular, we report a median disease-free survival and cancer-specific survival of 17 and 26 months, respectively, in the entire population. Although this might appear to be a limited survival rate, one must note that this is in a group of non-selected consecutive patients including 12.0% of palliative procedures, which are usually not included in other published series[6 12 23] (deemed a contraindication to pelvic exenteration for poor survival outcomes[24]), and 20.5% of laterally extended disease, which was considered a contraindication to radical surgery until recently.[25] Laterally extended endopelvic resection has been shown

Table 1 Clinico-pathological and surgical characteristics of study patients

Variables	MIS N (%)	Open N (%)	P value
All cases	39	78	–
Age, years, median (range)	63 (38–82)	58 (31–84)	0.15
BMI, kg/m^2, median (range)	25.6 (18.8–53.9)	24.8 (16.0–40.6)	0.15
ASA score			0.41
1	2 (5.1)	1 (1.3)	
2	35 (89.7)	71 (91.0)	
3	2 (5.1)	6 (7.7)	
Site of primary disease			0.05
Cervix	21 (53.8)	57 (73.1)	
Uterine corpus	11 (28.2)	15 (19.2)	
Vagina	4 (10.3)	5 (6.4)	
Vulva	3 (7.7)	0	
Ovary	0	1 (1.3)	
Time from diagnosis to pelvic exenteration, months	21 (1–288)	14 (1–282)	0.24
Surgical approach			<0.001
Laparotomy	0	78 (100.0)	
Laparoscopy	26 (66.7)	0	
Robotic	13 (33.3)	0	
Treatment(s) before pelvic exenteration			0.43
None	2 (5.1)	3 (3.8)	
Chemotherapy	3 (7.7)	3 (3.8)	
Surgery	7 (17.9)	11 (14.1)	
RT(CT)	13 (33.3)	41 (52.6)	
Surgery+CT	0	1 (1.3)	
Surgery+RT(CT)	14 (35.9)	19 (24.4)	
Type of exenteration (Magrina[8])			0.19
Supralevator	11 (28.2)	21 (26.9)	
Infralevator	25 (64.1)	56 (71.8)	
Infralevator with vulvectomy	3 (7.7)	1 (1.3)	
Type of exenteration			0.55
Anterior	25 (64.1)	45 (57.7)	
Total	14 (35.9)	33 (42.3)	
Surgical margin histology			0.54
Negative	31 (79.5)	68 (87.2)	
Microscopic	7 (17.9)	9 (11.5)	
Macroscopic	1 (2.6)	1 (1.3)	
Pelvic lymph node histology			1.0
Negative	34 (87.2)	68 (87.2)	
Positive	5 (12.8)	10 (12.8)	
Tumor diameter at histology, mm, median (range)	40 (15–120)	46 (2–150)	0.84
Adjuvant treatment			0.12
No	24 (61.5)	35 (44.9)	
Yes	15 (38.5)	43 (55.1)	

BMI, body mass index; CT, chemotherapy; MIS, minimally invasive surgery; RT, radiotherapy.

Table 2 Peri-operative outcomes

Variables	MIS N (range, %)	Open N (range, %)	P value
All cases	39	78	–
Duration of surgery, min, median (range)	563 (310–765)	540 (260–780)	0.26
Estimated intra-operative blood loss, mL, median (range)	500 (100–3500)	800 (150–3000)	0.52
Hospitalization, days, median (range)	14 (6–73)	18 (7–110)	0.20
Intra-operative complications*			0.13
No	35 (89.7)	59 (75.6)	
Yes	4 (10.3)	18 (23.1)	
Unknown	0	1 (1.3)	
Intra-operative transfusions			**0.013**
No	32 (82.1)	46 (59.0)	
Yes	7 (17.9)	32 (41.0)	
Early post-operative complications (<31 days)†			0.49
No–G2	32 (82.1)	59 (65.6)	
G3–G5	7 (17.9)	19 (24.4)	
Late post-operative complications (31–180 days)†‡			0.44
No–G2	34 (87.2)	62 (79.5)	
G3–G5	5 (12.8)	16 (20.5)	
Re-admission within 30 days			0.85
No	34 (87.2)	67 (85.9)	
Yes	5 (12.8)	11 (14.1)	

*Missing data in one patient.
†In case of multiple complications in the same patient, only the one with the highest grade is reported.
‡20/117 (17.1%) patients had a follow-up of <180 days and the complications were reported until the date of last follow-up.

to be a feasible procedure with interesting surgical and oncological outcomes,[26] but different series have shown that lateral disease represents a worse prognostic factor per se.[6 25] The high number of lateral involvements in the present series might have also contributed to impaired survival of our cohort.

As shown in previous studies, involvement of the surgical margin and tumor size at recurrence are the most important prognostic factors affecting disease-free survival and cancer-specific survival in patients with gynecological malignancies undergoing pelvic exenteration.[6 12 27] For this reason, patient selection and surgery planning with updated pre-operative imaging is crucial to obtain free surgical margins at final histology. All baseline characteristics were equalized in our population by propensity match analysis. This gave us the opportunity to compare patients with similar tumor diameter. In this context, we consider that tumor diameter together with pelvic sidewall involvement should be an important

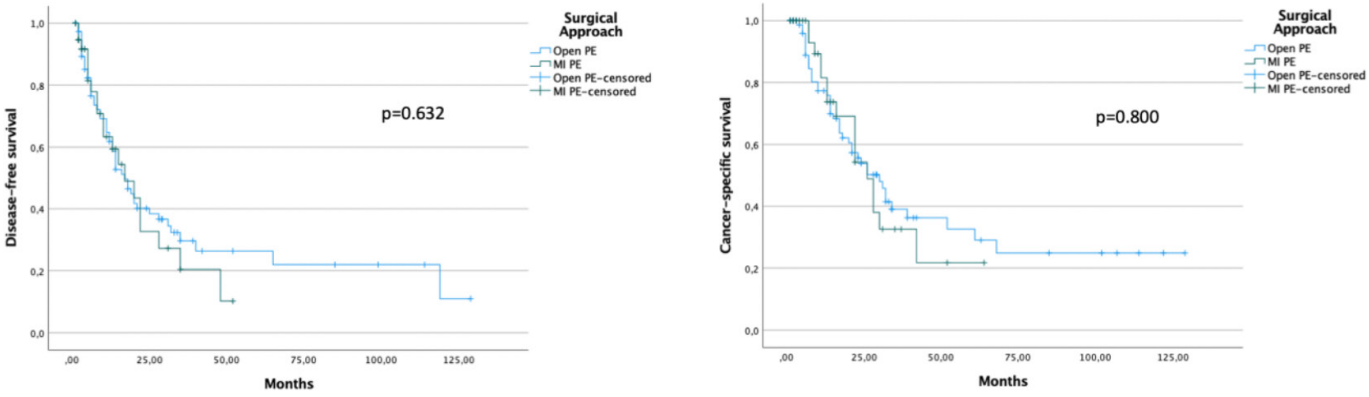

Figure 2 Disease-free (A) and cancer-specific (B) survival comparisons between patients undergoing open versus minimally invasive pelvic exenteration.

Table 3 Univariable Cox regression analysis for risk of recurrence and death of disease after pelvic exenteration*

	Recurrence		Death	
Variables	**HR (95% CI)**	**P value**	**HR (95% CI)**	**P value**
Positive pelvic lymph nodes	1.245 (0.645 to 2.439)	0.52	1.224 (0.598 to 2.507)	0.58
No†				
Yes				
Positive surgical margins	2.378 (1.313 to 4.308)	**0.004**	1.673 (0.885 to 3.163)	0.11
No†				
Yes				
Adjuvant therapy after PE	1.108 (0.682 to 1.800)	0.68	1.114 (0.657 to 1.887)	0.69
No†				
Yes				
Surgical approach	1.134 (0.671 to 1.918)	0.64	1.077 (0.603 to 1.925)	0.80
Laparotomy†				
Laparoscopic/robotic				
Tumor diameter at histology	1.492 (0.917 to 2.429)	0.11	1.833 (1.080 to 3.111)	**0.025**
<50 mm†				
≥50 mm				

*Multivariable analysis was not performed in view of only one significant variable at univariable analysis.
†Reference category.
HR, hazard ratio; PE, pelvic exenteration.

criterion in selecting patients for an open versus a minimally invasive approach. In fact, even though some reports have shown the feasibility of laterally extended pelvic resection by laparoscopy, this approach should be used with caution as achievement of free surgical margins cannot be compromised.[13 28]

When analyzing the surgical approach in gynecological cancer surgery, the results of the well-known randomized Laparoscopic Approach to Cervical Cancer (LACC) trial should always be noted.[29] However, this trial included patients with newly diagnosed early-stage cervical cancer while, in our series, most of the included patients (95.7%) had recurrent/persistent pelvic disease. Nevertheless, it is always crucial to follow the basic principles of oncological surgery, avoiding cancer cell spillage, careful specimen manipulation and resection of tumor-free tissues.

The results of the present study may be considered in a larger context of surgical oncology, including rectal and bladder cancer. In these settings, minimally invasive exenteration could be performed in highly selected cases with favorable patient anatomy and tumor characteristics, as it was associated with reduced intra-operative blood loss, shorter length of hospital stay, and reduced morbidity with no survival difference from the open approach in rectal and bladder cancer.[30–32]

Strengths and Weaknesses

Our study represents one of the largest series comparing oncologic outcomes in patients undergoing open versus minimally invasive pelvic exenteration. However, it does have some limitations: first, the retrospective nature of the study may have led to selection bias; second, the heterogeneity of primary origin of the included gynecological cancers makes survival comparison with other studies less reliable; and last, selection to open versus minimally invasive exenteration was performed according to the surgeon's preference and this may represent a further important selection bias.

Implications for Practice and Future Research

Overall, we believe that tumor site and size are important criteria in selecting patients for open pelvic exenteration. Patients with tumor diameter <5 cm and central pelvic recurrence could be ideal candidates for minimally invasive exenteration. It is also necessary to highlight the importance of performing this operation in referral centers with surgical expertise in both pelvic exenteration and in minimally invasive surgery.[33] A prospective trial assessing both oncological and peri-operative outcomes is needed, with the results of the present retrospective results used as hypothesis generating.

CONCLUSION

In a retrospective series of patients undergoing anterior/total pelvic exenteration for gynecological malignancies, no survival difference was evident when a minimally invasive approach was compared with an open approach. No difference was seen in peri-operative complications, but a higher intra-operative transfusion rate in the open group was evident. These results need to be taken with caution in view of the relatively low number of patients in the minimally invasive group. Involvement of surgical margins and tumor diameter at time of exenteration were the most important prognostic factors for disease-free survival and cancer-specific survival, respectively. Selection of patients for the minimally invasive approach should consider tumor size and location, and these characteristics should be assessed in prospective trials.

Author affiliations
[1]UOC Ginecologia Oncologica, Dipartimento per la salute della Donna e del Bambino e della Salute Pubblica, Fondazione Policlinico Agostino Gemelli IRCCS, Rome, Italy
[2]Department of Gynecologic Oncology, ARNAS "Civico – Di Cristina – Benfratelli", Department of Health Promotion, Mother and Child Care, Internal Medicine and Medical Specialties (PROMISE), University of Palermo, Palermo, Italy
[3]Unit of Gynecology and Obstetrics, Department of Human Pathology of Adult and Childhood "G. Barresi", Unit of Gynecology and Obstetrics, University of Messina, Messina, Italy
[4]Department of Medical Area (DAME), University of Udine, Udine, Friuli-Venezia Giulia, Italy
[5]Clinic of Obstetrics and Gynecology – "Santa Maria della Misericordia" University Hospital, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy

Presented at
The results of the present work have been presented as an oral presentation at the 31st Annual Congress of the European Society of Gynecological Endoscopy (ESGE), 2-5 October 2022 in Lisbon, Portugal and as a poster presentation at the 23rd International Meeting of the European Congress on Gynaecological Oncology (ESGO 2022), 27-30 October 2022 in Berlin, Germany.

Twitter Matteo Loverro @matteoloverro, Barbara Costantini @Barbara Costantini, Anna Fagotti @annafagottimd and Francesco Fanfani @frafanfani

Acknowledgements The authors would like to thank the surgical team and the scrub nurses at Policlinico Gemelli IRCCS, Rome, Italy and at ARNAS Ospedali Civico Di Cristina Benfratelli, University of Palermo, Palermo, Italy.

Contributors Conception of study: NB and GV. Design and development: NB, GV, and GSc. Data collection: ML, GSo, VC, EP, SGA, BC, VG, LT, AE, FF and AF. Data analysis: NB, GV, ML, and GSo. Preparation of tables: GV and NB. Initial draft of manuscript: NB, GV, GSc. Guarantor: NB, VC, GSc. Manuscript writing, review, and approval: all authors.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Policlinico Gemelli Ethical Committee (ID Number 0007958/21 on 03/03/2021). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

ORCID iDs
Nicolò Bizzarri http://orcid.org/0000-0002-1727-904X
Matteo Loverro http://orcid.org/0000-0002-9740-3169
Giulio Sozzi http://orcid.org/0000-0001-5847-8822
Anna Fagotti http://orcid.org/0000-0001-5579-335X
Francesco Fanfani http://orcid.org/0000-0003-1991-7284
Giovanni Scambia http://orcid.org/0000-0003-2758-1063

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Supplementary table 1. Number of minimally invasive pelvic exenteration in different time periods.

	TOTAL N (%)	***MIPE**** **N (%)**	***OPE**** **N (%)**	**p-value**
Period	117 (100)	39 (100)	78 (100)	0.033
2010-2013	17 (14.5)	1 (2.6)	16 (20.5)	
2014-2017	51 (43.6)	20 (51.3)	31 (39.7)	
2018-2021	49 (41.9)	18 (46.2)	31 (39.7)	

***MIPE: minimally invasive pelvic exenteration; ** OPE: open pelvic exenteration.**

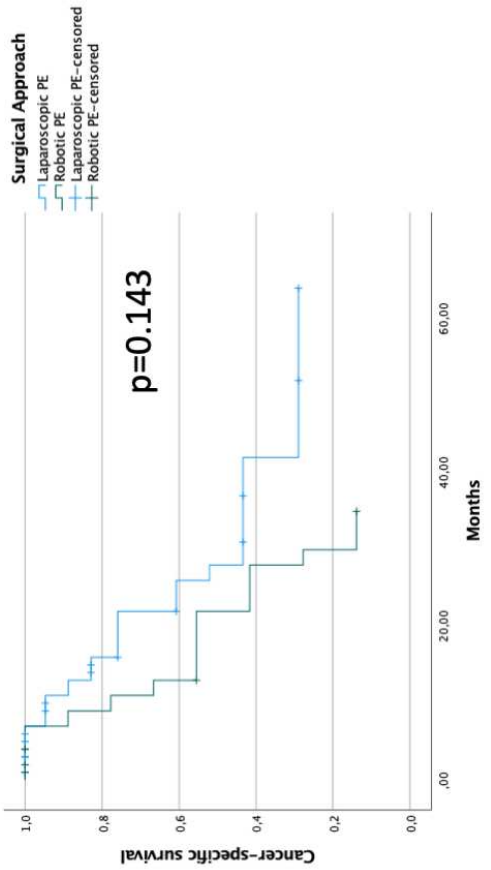
Supplementary table 2. Details of intra- and post-operative complications.

Complication	**TOTAL N (%)**	***MIPE**** **N (%)**	***OPE**** **N (%)**	**p-value**
Intra-operative complications[§]	22 (100)	4 (100)	18 (100)	0.697
- Vascular injury	17 (77.3)	4 (100)	13 (72.2)	
- Bowel injury	3 (13.6)	0	3 (16.7)	
- Ureter injury	1 (4.5)	0	1 (5.6)	
- Nerve injury	1 (4.5)	0	1 (5.6)	
Early post-operative complications[§]	105 (100)	23 (100)	82 (100)	0.752
- Wound dehiscence/infection	23 (21.9)	3 (13.0)	20 (24.4)	
- Blood transfusion	22 (21.0)	3 (13.0)	19 (23.2)	
- Abdominal/pelvic abscess/collection	17 (16.2)	6 (26.1)	11 (13.4)	
- Urinary sepsis	7 (6.7)	1 (4.3)	6 (7.3)	
- Ureteric fistula	6 (5.7)	2 (8.7)	4 (4.9)	
- Venous thromboembolism	5 (4.8)	2 (8.7)	3 (3.7)	
- Ureter stenosis	5 (4.8)	1 (4.3)	4 (4.9)	
- Bowel fistula	5 (4.8)	1 (4.3)	4 (4.9)	
- Ileus	5 (4.8)	2 (8.7)	3 (3.7)	
- Peritoneal bleeding	4 (3.8)	1 (4.3)	3 (3.7)	
- Stoma complications	2 (2.4)	1 (4.3)	1 (1.2)	
- Pleural effusion	2 (1.9)	0	2 (2.4)	
- Peripheral arterial ischemia	2 (1.9)	0	2 (2.4)	
Late post-operative complications[§]	53 (100)	15 (100)	38 (100)	0.532
- Ureter stenosis	12 (22.6)	5 (31.3)	7 (18.9)	
- Bowel obstruction (adhesions)	7 (13.2)	1 (6.3)	6 (16.2)	
- Abdominal/pelvic abscess/collection	6 (11.3)	2 (12.5)	4 (10.8)	
- Wound dehiscence/infection	6 (11.3)	1 (6.3)	5 (13.5)	
- Urinary sepsis	6 (11.3)	2 (12.5)	4 (10.8)	
- Incisional hernia	5 (9.4)	2 (12.5)	3 (8.1)	
- Venous thromboembolism	3 (8.1)	0	3 (8.1)	
- Bowel fistula	5 (9.4)	1 (6.3)	4 (10.8)	
- Ureteric fistula	1 (1.9)	1 (6.3)	0	

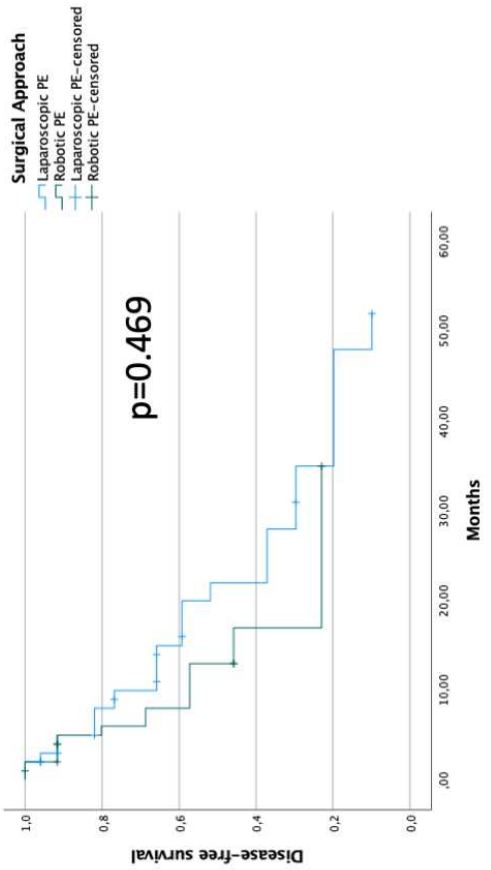
- Bowel ischemia	1 (1.9)	0	1 (2.7)	
- Lymphedema	1 (1.9)	0	1 (2.7)	

***MIPE: minimally invasive pelvic exenteration; ** OPE: open pelvic exenteration.**

§ One patient might have had more than one complication


Surgical Approach
Laparoscopic PE
Robotic PE
Laparoscopic PE–censored
Robotic PE–censored
p=0.143
Cancer-specific survival
1,0
0,8
0,6
0,4
0,2
0,0
,00
20,00
40,00
60,00
Months

B


Surgical Approach
Laparoscopic PE
Robotic PE
Laparoscopic PE–censored
Robotic PE–censored
p=0.469
Disease-free survival
1,0
0,8
0,6
0,4
0,2
0,0
,00
10,00
20,00
30,00
40,00
50,00
60,00
Months

A