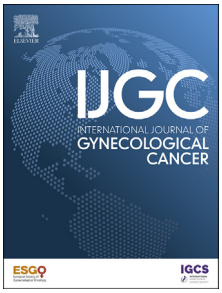
ORIGINAL RESEARCH

Evaluation of survival and mortality in pelvic exenteration for gynecologic malignancies: a systematic review, meta-analyses, and meta-regression study



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ABSTRACT

Objective: Pelvic exenteration is a radical surgery for advanced or recurrent pelvic tumors, requiring careful patient selection and a multi-disciplinary approach. Despite advancements, it remains high-risk, with limited data on outcomes. The present meta-analysis evaluates survival, mortality, and trends to clarify its role in gynecologic oncology.

Methods: A systematic search was conducted in January 2025 to identify studies on pelvic exenteration outcomes for gynecologic malignancies. Studies with at least 10 patients reporting 5-year overall survival or 30-day mortality were included. Data extracted included patient and surgical characteristics, and a scoring system based on study design, sample size, and center volume was used to include high-quality studies (score $\geq$3). Poisson regression models were used to analyze the associations between predictors and outcomes, with results expressed as incidence rate ratios and a 95% CI.

Results: A total of 46 studies involving 4417 patients met the inclusion criteria. Most patients underwent pelvic exenteration for cervical cancer ($N = 3183$). Positive pelvic and aortic nodal involvement were key predictors of reduced 5-year overall survival, decreasing by 3.9% and 5.9% per 1% increase in nodal positivity, respectively. Pelvic wall involvement also significantly reduced survival by 15.9%. The 30-day mortality rate was 5.1%, with sepsis (27.2%) being the leading cause of death. Peri-operative mortality decreased significantly over time, with each year of publication associated with a 2.6% decrease in incidence rate. However, pelvic sidewall involvement and total exenteration increased 30-day mortality by 11.5% and 0.7%, respectively.

Conclusions: Pelvic exenteration remains a viable but high-risk option for select patients with advanced gynecologic malignancies. Pre-operative assessment and multi-disciplinary planning are essential for optimizing outcomes.

Keywords:
Pelvic Exenteration; Gynecologic; Cervical Cancer; Endometrial Cancer; Vulvar Cancer

WHAT IS ALREADY KNOWN ON THIS TOPIC

Pelvic exenteration is a high-risk, radical procedure for recurrent gynecologic malignancies, with limited comprehensive data on survival and prognostic factors.

WHAT THIS STUDY ADDS

Pelvic wall involvement and aortic or pelvic lymph node metastases were significant predictors of reduced 5-year overall survival. In addition, pelvic sidewall involvement and total exenteration were associated with increased 30-day post-operative mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

These findings underscore the importance of individualized patient selection and comprehensive pre-operative assessment. Identifying high-risk features may guide clinicians toward more personalized treatment strategies that balance oncologic benefit with surgical risk. This evidence can enhance pre-operative counseling by providing patients with realistic expectations regarding outcomes and potential complications.

INTRODUCTION

Pelvic exenteration is a radical multi-visceral resection designed to treat locally advanced or recurrent pelvis tumors. It represents one of the most extreme surgical approaches in gynecologic oncology, often regarded as the last therapeutic option for patients with extensive or recurrent pelvic malignancies.[1,2] The original procedure was first described by Alexander Brunschwig in 1948 as an

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exceptionally radical surgical treatment for advanced and recurrent cervical cancer.[3] Since its introduction, this radical surgery has significantly evolved, with advancements in surgical techniques, peri-operative care, and technology leading to improved outcomes and fewer complications. However, pelvic exenteration remains associated with significant morbidity and mortality, requiring careful patient selection and a multi-disciplinary approach for its successful application.

Unfortunately, only a few retrospective reports have evaluated factors associated with survival or post-operative morbidity and mortality for pelvic exenteration, making it difficult to draw definitive conclusions on its indications and limits.[4-6] The lack of high-quality prospective data highlights the need for systematic reviews and meta-analyses to better define the role of pelvic exenteration in current clinical practice. The present analysis aimed to evaluate the 5-year overall survival and 30-day mortality and identify trends over the last 3 decades, providing insights into the evolving role of pelvic exenteration in the management of gynecologic malignancies.

METHODS

Search Strategy

In January 2025, 2 authors (EDA and RMA) independently performed a computerized search of Medline, CINAHIL, and Web of Science databases, as well as ClinicalTrials.gov, for data on the outcomes of pelvic exenteration for gynecologic cancers. In cases of disagreement, a third author (VDD) served as the tie-breaker. The inter-rater agreement between the 2 primary reviewers was assessed using the Cohen κ statistic, which resulted in a value of 0.92. The last search was conducted at the end of January 2025. The search strategy was designed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search query for Medline, for example, was constructed using the following Boolean operators: ("pelvic exenteration"[MeSH Terms] OR "pelvic exenteration") AND ("gynecologic"[All Fields] OR "cervical"[All Fields] OR "ovarian"[All Fields] OR "endometrial"[All Fields] OR "vulvar"[All Fields] OR "vaginal"[All Fields] OR "cancer"[All Fields]). The abstracts and, where appropriate, full text of articles and cross-referenced studies identified from retrieved articles were screened for pertinent information.

Selection of Studies

Key inclusion criteria were as follows: studies including at least 10 patients undergoing pelvic exenteration for recurrent or locally advanced gynecologic cancer and the presence of at least 1 of the following outcomes: 5-year overall survival and 30-day mortality rate. In case of overlap, the less recent study was excluded. If different outcomes were reported among the overlapping studies, a methodologic adjustment was applied to account for the overlap in the total patient count while preserving the information related to the reported outcomes.

In addition, studies that did not report at least 1 of the primary outcomes (5-year overall survival or 30-day mortality) were excluded, along with systematic reviews, meta-analyses, case reports, and editorials. Furthermore, studies explicitly stating that pelvic exenteration was performed solely with palliative intent and without curative potential were not included in the analysis.

For each eligible study cohort, the following information was recorded: age, year of publication, American Society of Anesthesiologists classification, Eastern Cooperative Oncology Group performance status score, number of patients, site of primary disease, disease-free interval (the time between the primary cancer treatment and the disease recurrence), type of recurrence, recurrence size, type of pelvic exenteration performed (anterior, posterior, or total), palliative or curative intent, pelvic and aortic nodal status, pelvic sidewall involvement, margins status, previous radiotherapy (RT), surgery-related results, and post-operative outcomes.

Methodologic Quality Assessment

Investigators carried out data extraction and quality assessment from all the retrieved studies based on full-text articles. Discrepancies between the investigators were resolved by consensus. A quality score was used to evaluate whether any studies were useful for the purpose of our analysis. The quality score was calculated by summing the singular score assigned to each of following variables: type of study (prospective $=$ 2, retrospective or population $=$ 1), total number of patients per study ($<50 = 1$; 50-100 $=$ 2; $>100 = 3$), volume of the center (number of patients per year of study: $<10 = 1$; 10-20 $=$ 2; $>20 = 3$). Given the methodologic heterogeneity among retrospective and prospective studies on pelvic exenteration, a customized scoring system was specifically developed for the present meta-analysis to ensure a more tailored and precise assessment of study quality. The methods ensure a systematic, transparent, and objective selection of high-quality studies, prioritizing reliability and relevance by using a clear scoring system based on study design, sample size, and center volume, while minimizing bias through consensus resolution. All studies with a quality score ≥ 3 were included. A detailed summary of the quality scores assigned to each included study is provided in Appendix S1. The present meta-analysis was registered in PROSPERO (International Prospective Register of Systematic Reviews), in accordance with PRISMA guidelines. The registration number is CRD420250656229.

Statistical Analysis

The primary outcomes of interest were 5-year overall survival and 30-day mortality rate. Univariable Poisson regression models were used to quantify the association between each of the potential predictors and each outcome of interest. The estimated associations were expressed as incidence rate ratios, demonstrating the changes in the incidence rate associated with changes in the predictor. Each estimated association was also plotted along with the observations from each study, weighted for their respective size, a common graphical output for meta-regression analyses. Although multi-variable Poisson regression models can be problematic when a modest number of studies is meta-analyzed, we decided to perform such an analysis if any statistically significant predictors were identified in the univariable models to assess the independent contribution of these variables to the outcome. An α level of 5% was used throughout and we report 95% CI for all estimates. Stata 18 (StataCorp) was used for all analyses. In accordance with the journal's guidelines, we will provide our data for independent analysis by a selected team by the Editorial Team

for the purposes of additional data analysis or for the reproducibility of this study in other centers if such is requested.

RESULTS

Of the 1465 initially screened citations, 46 studies, encompassing 4417 patients, met all inclusion criteria.[7-52] Some of the analyzed studies[39-42] exhibited an overlap in patient populations despite assessing different outcomes. To address this overlap and prevent data duplication, these studies were included because they analyzed different outcomes; however, in the overall patient count, each patient was considered only once.

The PRISMA flowchart illustrates the study selection process (Fig. S). The main characteristics of the studies included in the present analysis are detailed in Table 1 and Appendix S2. Briefly, 16 studies (34.8%), for a total of 1904 patients, were published between 1960 and 1999, whereas 30 studies (65.2%), for a total of 2513 patients, were published between 2000 and 2024. A total of 6 studies (13%), for a total of 457 patients, were prospective, and 40 studies (87%), for a total of 3960 patients, were retrospective. A total of 22 studies (47.7%), for a total of 2397 patients, were conducted in the United States, 19 studies (41.3%), for a total of 1756 patients, in Europe, 2 (4.4%), for a total of 119 patients, in South America, and 3 (6.6%), for a total of 145 patients, in Asia. The number of patients evaluated in each study ranged from 17 to 312 patients. A total of 4417 patients underwent pelvic exenteration and were considered: 3183 for cervical cancer, 252 for endometrial cancer, 249 for vulvar cancer, 365 for vaginal cancer, and 94 for ovarian cancer. The weighted mean age was 53.1 years (range; 45-61.9). A total of 36 studies, conducted on a total of 3326 patients, reported whether patients underwent previous RT or not. Previous RT was recorded for 2206 patients (66.3%). A total of 2 studies on 91 patients reported an Eastern Cooperative Oncology Group performance status score of 0 to 1. A total of 3 studies on 293 patients reported a median ASA (American Society of Anesthesiologists) score of 2, whereas 1 study on 77 patients reported a median ASA score of 3 for 24 patients. A total of 12 studies reported a median disease-free interval of 16.5 months. In all included studies, open pelvic exenteration was performed, except for 2 studies,[43,45] which reported only a total of 3 cases of robot-assisted surgery, making any sub-analysis impractical.

The type of pelvic exenteration performed was reported in 4417 patients: anterior pelvic exenteration in 1271 cases (28.8%), posterior pelvic exenteration in 455 cases (10.3%), and total pelvic exenteration in 2379 cases (53.9%). In 1 study including 312 patients,[7] the specific type of exenteration was not reported.

Lateral extended endopelvic resection was reported in 100 cases (2.2%). The reported median days of hospitalization varied widely between 4 and 210 days. The weighted mean blood loss was 1919.58 $\pm$ 955.1 mL (95% CI 47.6 to 3791.5). The results of the univariable Poisson regression analyses evaluating the association of each predictor variable with 5-year overall survival are shown in Table 2. Positive pelvic and aortic nodal involvement have been identified as significant negative predictors of 5-year overall survival (Fig. A). Each 1% increase in the rate of patients with positive pelvic and aortic nodes was associated with an estimated 3.9% and 5.9% decrease, respectively, in the incidence rate of 5-year overall survival (incidence rate ratio 0.961, 95% CI 0.926 to 0.997, $p = .034$ for pelvic nodes; incidence rate ratio 0.941, 95% CI 0.901 to 0.983, $p = .006$ for aortic nodes).

The pelvic nodal status was available for 19 cohorts, for a total of 2291 patients,[7,9,10,12,14,19,21,28-30,34-38,41,42,44,52] whereas aortic nodal status was available only for only 5, for a total of 473 patients.[30,34,36,44,52] Furthermore, pelvic wall involvement emerged as a negative predictor of survival, being associated with a 15.9% decrease in overall survival (incidence rate ratio 0.84, 95% CI 0.71 to 0.99, $p = .049$) (Fig. B). Moreover, the presence of locally

Table 1 Characteristics of the 46 Included Studies With a Total of 4417 Patients

Variable	*n* of studies	*n* of patients	Patients/total (%)
Publication y[a]			
1960-1969	2	359	8.1
1970-1979	3	656	15
1980-1989	8	579	13.1
1990-1999	3	310	7
2000-2009	8	752	17
2010-2019	15	1290	29.2
2020-2024	7	471	10.6
Country[a]			
USA	22	2397	54.3
Europe	19	1756	39.7
Sud America	2	119	2.7
Asia	3	145	3.3
Study design[a]			
Prospective	6	457	10.4
Retrospective	40	3960	89.6

Abbreviation: USA, United States of America.

[a] The reported data consider overlap in study 39 and 41.

advanced tumors was also identified as a significant negative predictor of 5-year overall survival. Specifically, each 1% increase in the rate of patients with locally advanced tumors was associated with an estimated 1.1% decrease in the incidence rate of 5-year overall survival (incidence rate ratio 0.99, 95% CI 0.98 to 0.99, $p <$ .001).

Occurrence of peri-operative mortality was reported for 35 patient cohorts, for a total of 3607 patients.[7-12,14-26,28-35,38,40,43-45,48,50,51] The weighted mean peri-operative mortality rate was 5.11 $\pm$ 8.05% (95% CI 0 to 40). The principal cause of death was reported in 25 cohorts, for a total of 2243 patients.[8,9,12,14-16,18,19,23-26,28-30,32,40,44-51] The primary causes of death included sepsis (27.2%), anastomotic leak (11.2%), pulmonary embolism (10.4%), respiratory failure (4.8%), and multi-organ failure (2.4%) (Table 3). The results of the univariable Poisson regression analyses evaluating the effect of each predictor variable on 30-day mortality are shown in Table 4. Peri-operative mortality decreased significantly over time, with each year of publication associated with a 2.6% decrease in incidence rate (incidence rate ratio 0.97, 95% CI 0.96 to 0.99, $p =$ .003) (Fig. C). Moreover, each 1% increase in the proportion of patients with pelvic side involvement was associated with a significant 11.5% increase in the incidence rate of mortality (incidence rate ratio 1.12, 95% CI 1.04 to 1.20, $p =$.003). In addition, each unit increase in the proportion of patients with total exenteration was associated with a 0.7% increase in the incidence rate of mortality (incidence rate ratio 1.01, 95% CI 1.00 to 1.01, $p =$ .004) (Fig. D).

DISCUSSION

Summary of Main Results

Our results indicate a survival benefit in selected patients (ie, those without pelvic sidewall involvement or nodal disease); however, the procedures performed are not without significant risks. Specifically, our findings highlight the detrimental impact of pelvic wall involvement and nodal metastases, which are strongly correlated with poorer survival and higher peri-operative mortality. Positive pelvic and aortic nodal involvement significantly reduced overall survival. Specifically, for every 1% increase in the proportion of patients with positive pelvic lymph nodes, the 5-year overall survival decreased by 3.9%. The impact was even more pronounced for aortic lymph node involvement, where a 1% increase led to a 5.9% drop in 5-year overall survival. These findings emphasize the importance of nodal assessment in pre-operative planning, with advanced imaging playing a crucial role in selecting candidates for radical surgery. The present analysis highlights pelvic wall involvement as a prognostic factor, associated with an 11.5% increase in peri-operative mortality for each 1% increase in the rate of pelvic wall involvement, along with higher post-operative morbidity. Pelvic wall involvement was associated with 5-year overall survival decrease of 15.9% for every 1% increase in pelvic wall involvement. The inverse proportionality between the year of publication and peri-operative mortality showed that the peri-operative mortality rate decreases by 2.6% for each subsequent year.

Results in the Context of Published Literature

The results of present analysis are consistent with the literature, which indicates that patients with negative lymph nodes have significantly higher survival rates, approximately double those of patients with positive lymph nodes.[30] In addition, the presence of pelvic lymph node metastases has been shown to reduce curative potential by half, emphasizing the prognostic significance of nodal involvement in survival outcomes for patients undergoing extensive surgical treatments.[37] Moreover, the present study aligns with previous literature emphasizing the technical challenges of achieving complete resection in cases of lateral extension. In the present analysis, lateral extension to the pelvic wall was correlated with 5-year overall survival. Furthermore, as noted in some recent studies,[53-55] although pelvic wall involvement remains a key negative prognostic indicator, achieving absent residual tumor poses a challenge in this sub-set of patients because it includes vessels, nerves, or bone resections. This emphasizes the necessity for a multi-disciplinary approach and referral to tertiary care centers for pelvic exenteration with pelvic side wall involvement to enhance peri-operative and survival rates outcomes.[53-57] Surgical margin involvement and tumor size are key determinants of disease-free survival in patients undergoing pelvic exenteration for gynecologic malignancies. This is particularly relevant in cases without lateral pelvic sidewall involvement and in recurrent disease.[56,57] These findings underscore the need to tailor surgical strategies to disease extent, considering less invasive approaches when appropriate, especially for patients with extensive disease.

Peri-operative mortality rates have steadily declined in recent years, likely attributable to improvements in peri-operative management, surgical techniques, and advancements in device technology. Given this continuous downward trend, the current mortality rate may be lower than the estimate provided. In the present analysis, the most frequently described cause of death was sepsis, followed by anastomotic leak, pulmonary embolism, and respiratory failure. Thus, although pelvic exenteration continues to be a valid choice with a 2-year overall survival rate of 51.1% and a 5-year overall survival of 30.8%, the mortality rate has notably decreased over the years; however, the incidence of surgical-related complications remains high, varying from 52.4% to 97%.[49,58] These observations highlight again the critical need for comprehensive pre-operative assessment and optimization to minimize post-operative risks.[59]

The adoption of minimally invasive approaches, including laparoscopy and robotic surgery, has gained popularity in recent years for pelvic exenteration. Although these techniques show promising results in reducing high-risk complications, such as sepsis and thromboembolic events, compared with open surgery, long-term oncologic outcomes remain to be fully validated, and prospective studies are needed to confirm their potential oncologic efficacy.[60-64] The present meta-analysis is not designed to address this specific question. Over time, pelvic exenteration has been widely used not only for the management of recurrent disease in previously treated patients but also for the treatment of locally advanced primary tumors. However, despite its role in achieving disease control, the outcomes appear to differ between these 2 groups. Moreover, the landscape of oncologic treatment has evolved significantly with the advent of targeted therapies, including immunotherapy, which are re-shaping the indications and timing for pelvic exenteration. Although surgery remains a crucial option for selected cases, the role of exenteration is being re-defined in an era where systemic therapies are becoming more

Table 2 Simple Poisson Regression Analysis Evaluating the Effect of Each Predictor Variable on 5-Year Overall Survival

Variable		Mean[a] ± SD	Median	IRR	95% CI	SE	% Increment	*p* Value	% Missing
Study time		15.239 ± 8.146	15	0.977	0.939 to 1.016	0.019	−2.30	.25	0
Accrual interval		7.383 ± 4.329	7.1	0.948	0.908 to 0.990	0.021	−5.20	.016	0
Year of publication		2003.217 ±15.923	2008	1.003	0.992 to 1.014	0.005	0.30	.56	0
Region reference[b]	US 22 (47.8%)								
	EU 19 (41.3%)	-	-	0.543	0.279 to 1.054	0.184	−45.7	.07	0
	Other 5 (10.9%)								
Mean age		53.152 ± 3.957	53	1.010	0.940 to 1.086	0.037	1.00	.77	54.35
Median age		56.773 ± 6.177	55	1.026	0.968 to 1.089	0.030	2.6	.37	58.7
Cervical cancer		76.355 ± 59.205	55	0.994	0.990 to 0.999	0.002	−0.60	.015	2.17
Endometrial cancer		6.209 ± 9.200	2	0.983	0.954 to 1.014	0.154	−1.70	.10	6.52
Vulvar cancer		6.256 ± 8.440	2	1.005	0.977 to 1.031	0.013	0.50	.72	6.52
Vaginal cancer		9.595 ± 11.173	6	0.999	0.983 to 1.017	0.009	−0.10	.96	8.70
Ovarian cancer		2.238 ± 8.932	0	0.908	0.860 to 0.958	0.254	−9.20	<.001	8.70
% Locally advanced[c]	(vs recurrence)	24.823 ± 30.674	13.6	0.989	0.983 to 0.994	0.002	−1.1	<.001	15.2
% Small tumor		52.076 ± 20.152	51.5	1.006	0.993 to 1.020	0.007	0.60	.38	73.91
% Positive margins		20.122 ± 15.048	15.9	0.971	0.924 to 1.020	0.024	−2.9	.25	54.35
% Pelvic wall involvement		25.270 ± 20.498	18.3	0.841	0.706 to 0.999	0.074	−15.90	.049	82.61
% Positive pelvic nodes		17.811 ± 10.283	14.3	0.961	0.926 to 0.997	0.018	−3.90	.034	58.69
% Positive aortic nodes		8.540 ± 12.010	1.88	0.941	0.901 to 0.983	0.020	−5.9	.006	89.13
n of pts with prior RT		63.861 ± 45.008	57.5	1.024	1.005 to 1.043	0.009	2.4	.012	21.74

Abbreviations: EU, European region; IRR, incidence rate ratio; Pts, patients; RT, radiotherapy; SE, standard error; SD, standard deviation; US, United States.

[a] Proportional to the number of patients in each study.

[b] The analysis compares the EU to the US as the reference group. Data from South America, Asia, and China were excluded.

[c] Percentage of patients with locally advanced tumors in each study over recurrences.

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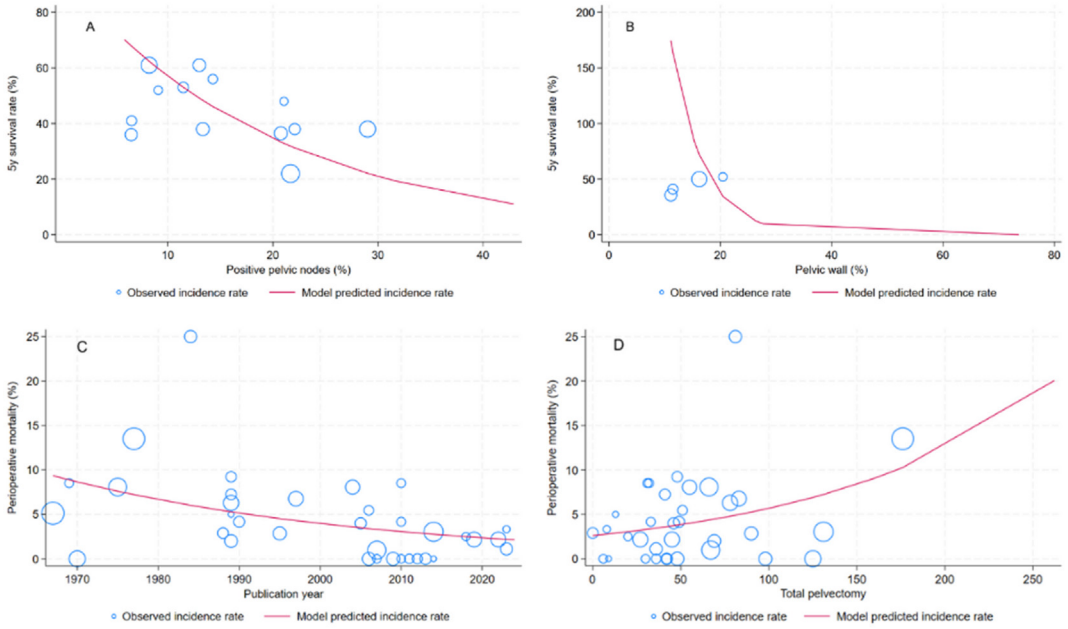

Figure Results of simple Poisson regression analyses. Circle size is proportional to the number of subjects in each study: **A,** Simple Poisson regression analysis showing 5-year survival rate against positive pelvic node. **B,** Simple Poisson regression analysis showing 5-year survival rate against pelvic wall involvement. **C,** Simple Poisson regression analysis showing peri-operative mortality rate against year of study publication. **D,** Simple Poisson regression analysis showing peri-operative mortality rate against total exenteration.

Table 3 Distribution of the Identified Causes of Death ($N = 125$) From 25 Studies of 2243 Patients

Cause of death	No. of deaths	*n*/total %	*n*/subgroup %
Infection	34		
Sepsis	34	27.2	100
Hematologic/vascular	29		
Pulmonary embolism	13	10.4	44.8
Ictus	3	2.4	10.3
Hemorrhage	11	8.8	38
Portal thrombosis	2	1.6	6.9
Organ failure	10		
Respiratory failure/pulmonitis	6	4.8	60
Liver failure	1	0.8	10
Multi-organ failure	3	2.4	30
Cardiovascular	12		
Myocardial infarction	8	6.4	66.7
CHD congestive heart failure	4	3.3	33.3
Gastrointestinal	14		
Anastomotic leak	14	11.2	100
Urinary	10		
Fistula	8	6.4	80
Renal insufficiency	2	1.6	20
Incidental cause	1		
Stradal accident	1	0.8	100
Surgical Procedure/other	15	12	100

Abbreviation: CHD, congestive heart failure.
References 8,9,12,14-16,18,19,23-26,28-30,32,40,44-51.

Table 4 Simple Poisson Regression Analysis Evaluating the Effect of Each Predictor Variable on 30-Day Mortality

Variable		Mean ± SD	Median	IRR	95% CI	SE	% Increment	*p* Value	% Missing values
Study time		15.239 ± 8.146	15	1.009	0.977 to 1.041	0.016	0.9	.57	0
Accrual interval		7.383 ± 4.329	7.1	1.022	0.969 to 1.077	0.027	2.2	.40	0
Year of publication		2003.217 ±15.923	2008	0.974	0.957 to 0.991	0.008	−2.6	.003	0
Location EU	US 22 (47.8%)								
	EU 19 (41.3%)	-	-	0.422	0.218 to 0.817	0.142	−57.8	.01	32.6
	Other 5 (10.9%)								
Mean age		53.152 ± 3.957	53	1.008	0.921 to 1.102	0.045	0.8	.86	54.35
Median age		56.773 ± 6.177	55	1.042	0.952 to 1.140	0.048	4	.36	58.7
Cervical cancer		76.355 ± 59.205	55	1.003	0.997 to 1.009	0.003	0.3	.24	2.17
Endometrial cancer		6.209 ± 9.200	2	0.983	0.958 to 1.008	0.012	−1.7	.18	6.52
Vulvar cancer		6.256 ± 8.440	2	1.007	0.956 to 1.060	0.026	0.7	.78	6.52
Vaginal cancer		9.595 ± 11.173	6	1.030	1.006 to 1.055	0.012	3	.014	8.70
Ovarian cancer		2.238 ± 8.932	0	0.978	0.951 to 1.005	0.014	−2.2	.12	8.70
% Small tumor		52.076 ± 20.152	51.5	0.999	0.967 to 1.031	0.016	−0.1	.96	73.91
% Positive margins		20.122 ± 15.048	15.9	1.005	0.980 to 1.031	0 .013	0.5	.66	54.35
% Pelvic wall involvement		25.270 ± 20.498	18.3	1.115	1.039 to 1.197	0.040	11.5	.003	82.60
% Positive pelvic nodes		17.811 ± 10.283	14.3	0.960	0.851 to 1.082	0.059	−4	.50	58.69
% Locally advanced	(vs recurrence)	24.823 ± 30.674	13.6	1.001	0.995 to 1.008	0.003	0.1	.61	15.2
n of pts with previous RT		63.861 ± 45.008	57.5	1.002	0.998 to 1.005	0.002	0.2	.25	21.74
Anterior exenteration		29.636 ± 25.870	20	1.006	0.992-1.020	0.007	0.6	.39	4.34
Posterior exenteration		11.325 ± 17.355	5	0.998	0.981 to 1.016	0.009	−0.2	.85	4.34
Total exenteration		58.568 ± 51.528	45.5	1.007	1.002 to 1.013	0.002	0.7	.004	4.34
Total number of complications		88.38 ± 75.93		0.997	0.989 to 1.005	0.004	−0.3	.58	43.24
Infective complications		27.706 ± 25.71	17.5	1.007	0.987 to 1.027	0.010	0.7	.46	26.1
Urinary complications		25.857 ± 31.46	15	1.002	0.974 to 1.031	0.014	0.2	.85	23.9
Gastrointestinal complications		24.5 ± 22.319	17	1.005	0.994 to 1.016	0.005	0.5	.36	21.7
Thromboembolic complications		4.12 ± 3.33	3	1.017	0.861 to 1.201	0.086	1.7	.84	45.65

Abbreviations: EU, European region; IRR, incidence rate ratio; Pts, patients; RT, radiotherapy; SE, standard error; SD, standard deviation; US, United States.
Total pelvic exenteration refers to the simultaneous removal of anterior and posterior compartments.

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effective. As novel treatment strategies continue to emerge, further research is needed to reassess the optimal integration of surgery within a modern multi-modal approach.

Strengths and Weaknesses

The strengths of the present analysis lie in the large sample size, with data on over 4000 patients from 46 studies, which provides robust statistical power and enables meta-regression analyses. Furthermore, the comprehensive assessment of prognostic factors provides valuable insights for clinical practice. In addition, advanced statistical analysis using Poisson regression models allows the independent contribution of each variable to clinical outcomes to be assessed. The use of a rigorous study quality assessment system helped to improve the robustness of the results, limiting the risk of bias. Although the study includes a large quantity of data, several limitations are known. Of the research considered, 90.4% were retrospective studies. This may introduce bias, such as potential confounding factors not considered prospectively. Furthermore, the large temporal variability between the included studies may affect the comparability of results.

A critical limitation in the collective evaluation of peri-operative morbidities is the absence, in many studies, of detailed reporting on the method and type of bladder or abdominal-perineal reconstruction performed after pelvic exenteration. This omission is significant because the choice of urinary diversion can profoundly influence peri-operative morbidity. For example, ileal conduit reconstruction is generally associated with a higher incidence of metabolic complications and stoma-related issues, whereas continent pouch reconstructions pose distinct risks, including higher rates of anastomotic leaks, urinary infections, and risk of sepsis. In addition, another limitation of the present study is the lack of data on minimally invasive surgery. Among the analyzed studies, only 2 assessed the role of minimally invasive surgery, and both did so in a highly limited patient cohort, preventing any meaningful analysis.

Implications for Practice and Future Research

The present meta-analysis highlights the importance of patient selection to address pelvic exenteration. Key prognostic indicators, such as nodal status and pelvic wall involvement, should guide clinical decisions, with nodal assessment particularly useful in determining eligibility for the procedure. The high peri-operative risks associated with total exenteration suggest that less invasive alternatives could be prioritized where appropriate. Contributions from this study highlight the need for tailored surgical strategies in gynecologic oncology, potentially influencing future guidelines. Prospective studies are encouraged to validate these findings and explore the impact of minimally invasive techniques and enhanced recovery protocols.

CONCLUSION

Pelvic exenteration remains a viable but high-risk option for advanced gynecologic malignancies, underscoring the critical role of thorough pre-operative assessment, advanced imaging, and multi-disciplinary planning to optimize outcomes. Advanced pre-operative evaluation to assess co-morbidities and risk factors associated with high morbidity, mortality, or poor prognosis should be mandatory.

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