

INCIDENCE AND RISK FACTORS FOR ANASTOMOTIC LEAKAGE AND RELATED COLORECTAL HEALING COMPLICATIONS FOLLOWING SURGERY FOR DEEP INFILTRATING ENDOMETRIOSIS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Anastomotic leakage and related colorectal healing complications, including dehiscence and bowel or rectovaginal fistula, are uncommon but serious complications of colorectal surgery for deep infiltrating endometriosis. Evidence concerning their incidence and risk factors is limited. The objective is to estimate the incidence of these complications and identify associated patient-, disease-, and procedure-related factors. **Materials and Methods:** MEDLINE/PubMed and Europe PMC were searched through 30 June 2026. Eligible observational studies reported leakage, dehiscence, bowel fistula, or rectovaginal fistula after colorectal surgery for deep infiltrating endometriosis. Random-effects models generated pooled proportions, odds ratios (ORs), and mean differences (MDs). Outcome-restricted and leave-one-out sensitivity analyses were performed. ROBINS-I principles and GRADE informed appraisal. **Result:** Six cohorts (5,770 patients) contributed to the incidence analysis. The pooled incidence of author-defined leakage, dehiscence, or related fistula was 3.3% (95% confidence interval [CI], 2.4-4.6%; $I^2 = 70.6\%$). The Flammang study reported 10.2%; excluding it yielded 2.9% (95% CI, 2.5-3.4%; $I^2 = 0\%$), showing substantial influence on heterogeneity but little influence on the central estimate. Segmental resection versus shaving (OR, 5.17; 95% CI, 1.99-13.45; two studies) and vaginal excision/opening (OR, 2.47; 95% CI, 1.26-4.83; two studies) showed higher crude odds. Operations with leakage/fistula were longer (MD, 73.08 minutes; 95% CI, 41.92-104.24; two studies). Very low anastomosis, levator ani involvement, malnutrition, and *Clostridioides difficile* infection were exploratory risk signals from individual cohorts and should be interpreted cautiously. The higher crude event rate among patients with protective diversion reflected preferential stoma use in higher-risk cases and did not represent a causal effect of the stoma. **Conclusion:** These complications occur after approximately 3% of colorectal operations for deep infiltrating endometriosis. Technically complex procedures may carry greater risk, but several large estimates are based on few events and very-low-certainty evidence. Standardized outcomes and adjusted prospective studies are required.

INTRODUCTION

Endometriosis is a chronic, estrogen-dependent inflammatory disorder characterized by the presence of endometrial-like tissue outside the uterine cavity. Deep infiltrating endometriosis represents one of its most severe phenotypes and may involve the rectovaginal septum, uterosacral ligaments, vagina,

urinary tract, and bowel. Intestinal lesions occur predominantly in the rectum and rectosigmoid junction and may cause dyschezia, cyclical changes in bowel habits, rectal bleeding, chronic pelvic pain, dyspareunia, and infertility. Surgery may be considered when symptoms remain severe despite medical treatment, bowel stenosis is clinically significant, organ function is threatened, or

anatomical restoration is required as part of fertility management.^[1]

The principal surgical techniques for colorectal endometriosis are rectal shaving, discoid excision, and segmental colorectal resection. Rectal shaving removes disease from the external bowel wall without intentionally opening the lumen and is generally used for smaller or more superficial lesions. Discoid excision involves full-thickness removal of a localized lesion followed by closure of the bowel-wall defect. Segmental resection removes the affected bowel segment and requires construction of a colorectal anastomosis. Procedure selection is influenced by lesion size, depth, circumference, multifocality, distance from the anal verge, degree of stenosis, and involvement of adjacent structures. Previous reviews have demonstrated that postoperative morbidity varies among these techniques, although direct comparisons are strongly affected by differences in disease severity and surgical selection.^[2-4]

Anastomotic leakage and related colorectal healing complications are among the most serious adverse outcomes of colorectal surgery. They may result in pelvic abscess, peritonitis, sepsis, bowel or rectovaginal fistula, reoperation, prolonged hospitalization, and temporary or permanent diversion. These complications may also delay fertility treatment and negatively affect long-term bowel function, psychological well-being, and quality of life. These consequences are especially important because most patients undergoing surgery for endometriosis are young and are receiving treatment for benign disease.^[5]

The reported incidence of leakage following colorectal surgery for deep infiltrating endometriosis varies substantially. Differences in operative technique, anastomotic height, patient selection, disease complexity, postoperative surveillance, and duration of follow-up contribute to this variation. Comparison among studies is further complicated by inconsistent outcome definitions. Some studies restrict leakage to radiologically, endoscopically, or surgically confirmed anastomotic disruption, whereas others include bowel fistula or rectovaginal fistula within a broader composite outcome.

Risk factors established in colorectal cancer surgery cannot be applied directly to patients with endometriosis. Patients with endometriosis are generally younger, have fewer systemic comorbidities, and are not exposed to malignancy-related cachexia, radiotherapy, or cytotoxic chemotherapy. Conversely, endometriosis surgery may involve severe pelvic fibrosis, obliteration of tissue planes, extensive adhesiolysis, very low rectal dissection, vaginal opening, urinary tract procedures, and simultaneous excision of multiple pelvic lesions. Contemporary observational studies have identified several potential risk factors for anastomotic leakage or related fistula. These include bowel-lumen opening during discoid excision or segmental resection, low or ultralow anastomotic height,

concomitant vaginal excision, levator ani involvement, prolonged operative duration, nutritional compromise, and postoperative infection. However, findings have not been consistent across studies, and several large crude odds ratios are based on small exposed groups and few events. These findings should therefore be regarded as exploratory signals rather than precise causal estimates.^[6-12]

The role of protective diversion remains uncertain. A temporary ileostomy or colostomy may reduce fecal contamination and the clinical severity of pelvic sepsis without necessarily preventing the underlying anastomotic defect. However, diversion is preferentially performed for low, technically demanding, or poorly perfused anastomoses, producing substantial confounding by indication. Stoma formation is also associated with dehydration, obstruction, electrolyte disturbances, psychological burden, and complications related to reversal.^[13]

Preoperative nutritional assessment may be particularly relevant because malnutrition and hypoalbuminemia can impair collagen synthesis, immune function, tissue oxygenation, and wound healing. Nutritional screening and correction of clinically significant deficiencies are consistent with enhanced-recovery recommendations for patients undergoing elective colorectal surgery.^[14]

Previous systematic reviews primarily compared surgical techniques or summarized overall postoperative morbidity. Since their publication, several large multicenter and specialist-center cohorts have provided additional information regarding leakage incidence and potential patient-, disease-, and procedure-related risk factors. An updated evidence synthesis is therefore required. Such a review should also account for variation in outcome definitions and encourage adoption of standardized anastomotic leakage definitions and severity grading.^[15]

The primary objective of this systematic review and meta-analysis was to estimate the incidence of anastomotic leakage and related colorectal healing complications, defined as author-reported leakage, dehiscence, or attributable bowel or rectovaginal fistula, following colorectal surgery for deep infiltrating endometriosis. The secondary objective was to identify patient-, disease-, and procedure-related risk factors for these complications. Additional objectives were to evaluate heterogeneity among studies, assess the certainty of the available evidence, and identify priorities for future risk-prediction and prevention research.

MATERIALS AND METHODS

Study design and protocol: A systematic review and meta-analysis were conducted to identify risk factors associated with anastomotic leakage following colorectal surgery for deep infiltrating endometriosis. The review was performed in accordance with the Preferred Reporting Items for Systematic Reviews

and Meta-Analyses (PRISMA) 2020 statement and the Meta-analysis of Observational Studies in Epidemiology reporting recommendations. The review protocol was developed before study selection and data synthesis but was not prospectively registered.

Eligibility criteria: Studies were eligible if they included adult women undergoing colorectal surgery for clinically or histologically confirmed deep infiltrating endometriosis involving the rectum, rectosigmoid junction, sigmoid colon, or another colorectal segment. Eligible procedures included rectal shaving, discoid excision, and segmental colorectal resection performed through laparoscopic, robotic, open, or combined approaches. Studies were required to report either the incidence of anastomotic leakage, dehiscence, bowel fistula, or rectovaginal fistula attributable to colorectal surgery, or sufficient comparative data to evaluate at least one potential risk factor. Randomized trials, prospective or retrospective cohort studies, case-control studies, and consecutive surgical series containing at least 20 patients were considered. Case reports, small case series, reviews, editorials, technical reports without outcome denominators, conference abstracts with insufficient numerical data, and mixed-indication studies without separately extractable endometriosis data were excluded. When publications contained overlapping populations, the largest or most informative dataset was retained for each analysis.

Information sources and literature search: MEDLINE/PubMed and Europe PMC were searched from database inception to June 30, 2026. The search combined controlled vocabulary, where available, and free-text terms relating to deep infiltrating endometriosis, colorectal involvement, surgical treatment, anastomotic leakage, and risk factors. The principal search terms included “endometriosis,” “deep infiltrating endometriosis,” “colorectal,” “rectal,” “rectosigmoid,” “bowel,” “rectal shaving,” “discoid excision,” “segmental resection,” “anastomotic leakage,” “anastomotic dehiscence,” “bowel fistula,” “rectovaginal fistula,” “risk factor,” and “predictor.” Boolean operators and database-specific syntax were used to combine the terms. A supplementary search using broader terms for colorectal resection and postoperative morbidity was performed to identify studies reporting leakage within overall surgical complications. Reference lists of eligible articles and relevant systematic reviews were manually examined for additional studies. No language restrictions were applied during the initial search, although inclusion required sufficient information for reliable eligibility assessment and data extraction.

Study selection: Search results were imported into reference-management software, and duplicate records were removed. Two reviewers independently screened the titles and abstracts of all retrieved records. Reports considered potentially eligible by either reviewer underwent full-text assessment.

The same reviewers independently evaluated the full-text articles using the prespecified eligibility criteria. Disagreements were resolved through discussion and consensus. Reasons for excluding reports during full-text assessment were documented. The study-selection process was presented in a PRISMA flow diagram.

Data extraction: Two reviewers independently extracted data using a standardized and piloted data-extraction form, with disagreements resolved through discussion and consensus. Extracted information included the first author, publication year, country, study design, recruitment period, surgical setting, sample size, patient characteristics, anatomical location and extent of endometriosis, operative approach, type of colorectal procedure, anastomotic technique and height, concomitant vaginal or urinary tract surgery, protective stoma formation, operative duration, blood loss, leakage definition, diagnostic method, follow-up period, and number of anastomotic leakage, dehiscence, bowel fistula, or rectovaginal fistula events. Data for potential patient-, disease-, and procedure-related risk factors were recorded together with unadjusted and adjusted effect estimates and their 95% confidence intervals. Adjusted estimates were preferred for interpretation when available. When only raw frequency data were reported, odds ratios were calculated from two-by-two tables. For studies reporting percentages without event counts, the number of events was reconstructed from the reported denominator and percentage. Authors were contacted when essential information was missing or unclear.

Outcome definition: The primary outcome was clinically relevant anastomotic leakage following colorectal surgery for deep infiltrating endometriosis. Anastomotic leakage was defined as a defect of the colorectal wall at the anastomotic site resulting in communication between the intraluminal and extraluminal compartments, diagnosed clinically, radiologically, endoscopically, or during reoperation. Because definitions varied among studies, the outcome definition reported by each study was accepted. Pelvic abscess, feculent drainage, bowel fistula, or rectovaginal fistula was included when explicitly attributed to anastomotic disruption or failure of colorectal healing. A sensitivity analysis using a stricter outcome definition included only confirmed anastomotic leakage or dehiscence and excluded isolated rectovaginal fistulas when separate data were available. Secondary outcomes included the associations between leakage and patient-related, disease-related, and procedure-related risk factors.

Risk-of-bias assessment: Two reviewers independently assessed the methodological quality of the included observational studies using the Risk Of Bias In Non-randomized Studies of Interventions framework. The evaluated domains included bias due to confounding, participant selection, classification of surgical exposures, deviations from intended procedures, missing data, outcome measurement, and selective reporting. Particular attention was given to

confounding by disease severity, anastomotic height, and operative complexity because these factors influenced the selection of surgical technique and protective diversion. Each study was classified as having low, moderate, serious, or critical risk of bias or insufficient information for judgment. Disagreements between reviewers were resolved through discussion and consensus, with consultation of a third reviewer when required. Risk-of-bias judgments were considered when interpreting the pooled estimates and evaluating the certainty of evidence.

Statistical analysis: The incidence of anastomotic leakage or related colorectal healing complications was calculated by dividing the number of events by the total number of eligible colorectal procedures. Study-specific proportions were transformed to the logit scale and pooled using a DerSimonian-Laird random-effects model, with summary estimates subsequently back-transformed and reported as pooled incidences with 95% confidence intervals. Associations between dichotomous risk factors and leakage or fistula were expressed as odds ratios, while continuous variables were summarized as mean differences, each with 95% confidence intervals. A continuity correction of 0.5 was applied when a two-by-two table contained a zero cell. Statistical heterogeneity was assessed using Cochran's Q test and quantified with the I^2 statistic. Sensitivity analyses excluded isolated rectovaginal fistulas, studies at serious or critical risk of bias, potentially overlapping cohorts, and, in a leave-one-out analysis, the study with the highest event rate. Subgroup analysis and meta-regression were planned only when sufficient studies were available. Publication bias was not formally assessed for analyses involving fewer than 10 studies. All tests were two-sided, with $P < 0.05$ considered statistically significant. Analyses were implemented using reproducible Python scripts.

Certainty of evidence: The certainty of evidence for each major outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation approach. Evidence from observational studies initially received a low-certainty rating and was downgraded for serious risk of bias, inconsistency, indirectness, imprecision, or publication bias. Upgrading was considered when there was a large effect size, evidence of a dose-response relationship, or plausible residual confounding that would reduce the observed association.

Ethical considerations: Ethics committee approval and individual informed consent were not required because the review used aggregate data from previously published studies and did not involve identifiable patient information.

RESULTS

Study selection: The electronic searches identified 100 records. After removal of 11 duplicates, 89 unique records underwent title and abstract screening. Seventy-one records were excluded because they did not meet the eligibility criteria. Eighteen full-text reports were assessed, of which 11 were excluded: six did not provide extractable leakage or risk-factor data, three involved overlapping patient cohorts, and two were conference abstracts with insufficient numerical information. Seven studies were included in the qualitative synthesis. Six non-overlapping or minimally overlapping cohorts contributed to the pooled incidence analysis. One prospective cohort overlapped with a larger subsequent institutional series and was retained only for the qualitative evaluation of nutritional and postoperative diagnostic factors. The study-selection process is shown in [Figure 1].

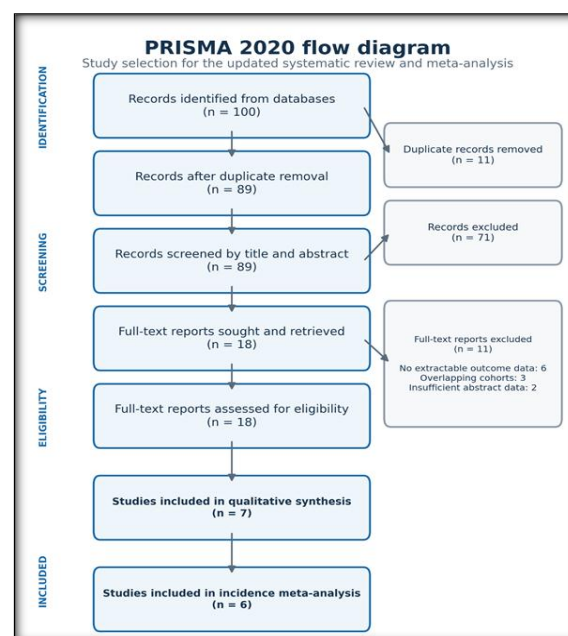


Figure 1: PRISMA flow diagram

Figure legend: PRISMA flow diagram showing identification, screening, eligibility assessment, and inclusion of studies in the systematic review and meta-analysis.

Study characteristics: The seven included studies were prospective, retrospective, or combined retrospective-prospective observational cohorts. Most were conducted in European tertiary referral or specialist endometriosis centers. Sample sizes ranged from 88 patients with colorectal anastomoses to 3,050 patients undergoing segmental rectosigmoid resection.

The surgical procedures included rectal shaving, discoid excision, segmental colorectal resection, and combinations of these techniques. Most operations were performed laparoscopically. Concomitant procedures included vaginal excision, ureterolysis,

urinary tract surgery, hysterectomy, and excision of parametrial or other pelvic endometriotic lesions. Definitions of anastomotic complications varied among studies. Some studies restricted the outcome to radiologically, endoscopically, or surgically confirmed anastomotic leakage, whereas others used a broader composite outcome that included

anastomotic dehiscence, bowel fistula, or rectovaginal fistula. Study characteristics are summarized in [Table 1]

Table 1: Characteristics of included studies

Study	Design	Sample size	Colorectal procedures	Anastomotic/healing outcome
Roman et al., 2020	Retrospective analysis of prospectively recorded multicenter data	1,102	Shaving, discoid excision, segmental resection and combined procedures	37 bowel fistulas: 14 leaks and 23 rectovaginal fistulas
Bertocchi et al., 2022	Prospective single-center cohort	262	Laparoscopic colorectal resection	8 leaks (3.2%); nutritional and postoperative diagnostic factors evaluated
Hudelist et al., 2022	Retrospective cohort involving 19 expert centers	937	Shaving, discoid excision and segmental resection	19 anastomotic leaks (2.0%)
Casas et al., 2023	Retrospective single-center cohort	168	57 shaving, 23 discoid excisions and 88 segmental resections	5 leaks; all occurred after segmental resection
Ceccaroni et al., 2023	Retrospective 17-year referral-center cohort	3,050	Segmental rectosigmoid resection	Anastomotic leakage, 3.0%; rectovaginal fistula, 1.9%
Nowak et al., 2026	Retrospective-prospective single-center cohort	425	43 shaving, 84 discoid excisions and 294 segmental resections	12 dehiscence events, including 10 rectovaginal fistulas
Flammang et al., 2026	Retrospective interdisciplinary cohort	118; 88 with anastomoses	30 shaving procedures, 7 sigmoid resections and 81 rectal resections	9 leaks among 88 anastomoses (10.2%)

Risk of bias: The overall risk of bias ranged from moderate to serious. Several studies used consecutive patient inclusion and prospectively maintained surgical databases, reducing concerns regarding selection bias. Anastomotic complications were generally confirmed by imaging, endoscopy, reoperation, or direct clinical evidence. The principal methodological concern was confounding by disease severity and operative complexity. Segmental resection, very low

anastomosis, vaginal opening, and protective diversion were more frequently performed in patients with extensive or anatomically complex disease. Many risk-factor analyses were unadjusted and included relatively few leakage events. Outcome definitions, diagnostic protocols, and follow-up periods also differed among studies. No included study randomized patients according to the exposures under investigation. The risk-of-bias assessment is presented in [Table 2]

Table 2: Risk-of-bias assessment

	Participant selection	Confounding	Outcome measurement	Overall risk
Roman et al., 2020	Moderate	Serious	Moderate	Moderate
Bertocchi et al., 2022	Low-moderate	Moderate	Low	Moderate
Hudelist et al., 2022	Moderate	Serious	Moderate	Moderate
Casas et al., 2023	Moderate	Serious	Moderate	Serious
Ceccaroni et al., 2023	Moderate	Moderate	Moderate	Moderate
Nowak et al., 2026	Moderate	Serious	Low-moderate	Serious
Flammang et al., 2026	Moderate	Serious	Low	Serious

Incidence of anastomotic leakage and related colorectal healing complications
Six cohorts comprising 5,770 patients and approximately 174 author-defined anastomotic leakage, dehiscence, or related fistula events contributed to the primary analysis. The random-effects pooled incidence was 3.3% (95% confidence interval [CI] 2.4-4.6%), with substantial heterogeneity ($I^2 = 70.6\%$).
The incidence in individual studies ranged from 2.0% to 10.2%. The highest rate was reported by Flammang et al. (9/88 anastomoses; 10.2%), a relatively small specialist-center cohort. In a leave-one-out analysis excluding this study, the pooled incidence was 2.9% (95% CI 2.5-3.4%) and heterogeneity fell to $I^2 = 0\%$. Thus, the Flammang

study had a substantial impact on heterogeneity but only a modest impact on the pooled incidence. A sensitivity analysis restricted to four studies reporting anastomotic leakage separately from other fistulas produced a pooled incidence of 3.6% (95% CI 2.0-6.2%; $I^2 = 82.0\%$). Exclusion of isolated rectovaginal fistulas therefore did not materially alter the central incidence estimate, although heterogeneity and statistical uncertainty increased.

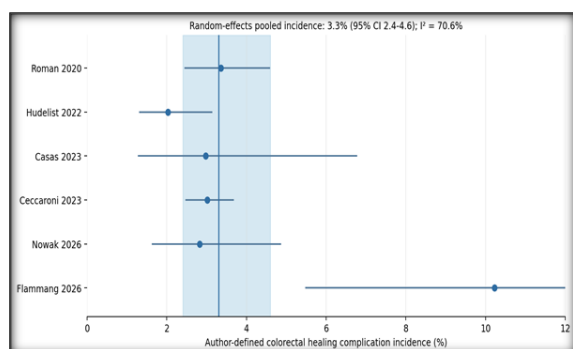


Figure 2: Pooled incidence of anastomotic leakage and related colorectal healing complications.

Random-effects meta-analysis of author-defined anastomotic leakage, dehiscence, or related bowel or rectovaginal fistula following colorectal surgery for deep infiltrating endometriosis. Squares represent individual-study estimates, horizontal lines represent 95% confidence intervals, and the shaded area represents the 95% confidence interval of the pooled estimate. The higher estimate in Flammang et al. influenced heterogeneity but did not materially change the pooled incidence in leave-one-out analysis.

Procedure-related factors

Type of colorectal procedure: Two cohorts provided compatible data comparing segmental colorectal resection with rectal shaving. Segmental resection was associated with higher crude odds of leakage or bowel fistula than rectal shaving (odds ratio [OR] 5.17, 95% CI 1.99-13.45; two studies). Because procedure selection reflected lesion severity and complexity, this estimate should not be interpreted as a fully adjusted causal effect.

In a multicenter cohort of 1,102 patients, the adjusted odds of bowel fistula were higher following discoid excision (adjusted OR 6.8, 95% CI 1.9-23.8), segmental resection (adjusted OR 4.8, 95% CI 1.4-16.9), and combined discoid and segmental resection (adjusted OR 11.0, 95% CI 2.1-58.6) compared with rectal shaving.

In another cohort of 168 patients, all five leakage events occurred following segmental resection, whereas no leakage occurred following rectal shaving or discoid excision. Procedure selection was influenced by lesion size, depth, multifocality, and stenosis; therefore, residual confounding by disease severity could not be excluded.

Anastomotic height: Low anastomotic height was identified as a potential risk signal, but the available estimates were based on few events. In the largest cohort, low anastomosis, defined as less than 8 cm from the anal verge, and ultralow anastomosis, defined as 5 cm or less, were associated with major postoperative complications; the precision and independence of this association remain uncertain.

In another cohort, fistula occurred in eight of 90 patients with anastomoses below 8 cm compared with two of 204 patients with anastomoses at or above 8 cm. The corresponding crude OR was approximately

9.85. The highest event frequency was observed for anastomoses located 5-6 cm from the anal verge, with four events among only 10 patients. These sparse data support cautious interpretation of the magnitude of association.

Concomitant vaginal surgery: Two studies reported compatible data for concomitant vaginal excision or vaginal-lumen opening. Vaginal surgery was associated with higher crude odds of leakage or fistula (OR 2.47, 95% CI 1.26-4.83; two studies), although residual confounding by disease extent and operative complexity remained likely.

One study reported bowel fistula in 4.7% of patients undergoing vaginal excision compared with 2.1% of patients without vaginal excision. After adjustment, the association was attenuated and no longer statistically significant (adjusted OR 1.9, 95% CI 0.92-3.9).

Another study reported two fistulas among 12 patients undergoing vaginal-lumen opening during segmental resection, compared with one fistula among 37 patients undergoing vaginal resection without lumen opening.

Advanced pelvic disease: Levator ani involvement was evaluated in one cohort. Leakage or fistula occurred in six of 21 patients with levator ani involvement compared with four of 400 patients without such involvement, corresponding to a crude OR of approximately 39.6. Because this estimate arose from a small exposed group and only 10 events, its magnitude is highly uncertain and may chiefly reflect very low, laterally extensive disease and complex pelvic dissection rather than an independent causal effect.

Operative duration: Two cohorts reported operative duration according to leakage status. Operations in patients who developed leakage or fistula were, on average, 73.08 minutes longer than operations in patients without these complications (95% CI 41.92-104.24; two studies). This association should be interpreted primarily as a marker of disease extent, adhesiolysis, multivisceral surgery, and technical difficulty rather than as an independent causal effect.

Protective diversion: Three cohorts reported leakage or fistula according to protective stoma formation. In the unadjusted analysis, patients selected for protective diversion had higher crude odds of leakage or fistula (OR 2.96, 95% CI 1.67-5.27; three studies). This comparison is strongly confounded because stomas were preferentially used in higher-risk cases.

The higher crude event rate among patients with a stoma should therefore be understood as a consequence of confounding by indication: diversion was preferentially performed for very low anastomoses, combined vaginal surgery, extensive disease, or intraoperative concern regarding anastomotic integrity. It does not indicate that the stoma itself increases the risk of anastomotic failure. Diversion may reduce fecal contamination or the clinical severity of a leak even when it does not prevent the underlying defect.

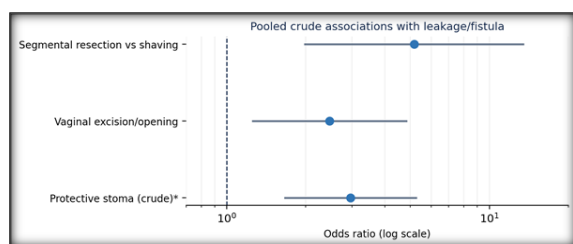


Figure 3: Pooled associations between surgical factors and leakage or fistula.

Effect estimates are presented as crude odds ratios with 95% confidence intervals on a logarithmic scale. For protective diversion, the higher crude event rate reflects selection of higher-risk patients for a stoma (confounding by indication) and does not represent a harmful causal effect of the stoma.

Patient-related and postoperative factors: Age, body mass index, smoking status, previous pelvic surgery, and common comorbidities were not consistently associated with anastomotic leakage. The estimates were heterogeneous and were frequently based on small numbers of events.

Preoperative nutritional risk was associated with postoperative leakage in one prospective cohort. Lower preoperative serum albumin was also identified as a potential risk factor, but insufficient numerical data were available for quantitative pooling.

Postoperative *Clostridioides difficile* infection was associated with fistula formation in one cohort. Fistula occurred in three of 20 patients with *C. difficile* infection compared with seven of 401 patients without infection, corresponding to a crude OR of approximately 9.93. The temporal relationship between infection and early anastomotic disruption was unclear.

Serial Dutch Leakage Scores, C-reactive protein concentrations, and procalcitonin concentrations were associated with the early identification or exclusion of anastomotic leakage. These variables were regarded as postoperative diagnostic markers rather than preoperative risk factors.

The quantitative findings are summarized in [Table 3]

Table 3. Summary of quantitative findings

Outcome or risk factor	Evidence	Effect estimate (95% CI)	Heterogeneity	Certainty	Interpretation
Overall anastomotic leakage/dehiscence/related fistula incidence	6 cohorts; 5,770 patients	3.3% (2.4–4.6%)	$I^2 = 70.6\%$	Low	Definitions and procedure types varied; Flammang et al. drove most heterogeneity
Strict leakage incidence	4 cohorts	3.6% (2.0–6.2%)	$I^2 = 82.0\%$	Low	Isolated rectovaginal fistulas excluded; estimate remained similar but imprecise
Segmental resection versus shaving	2 cohorts	OR 5.17 (1.99–13.45)	Not estimated ($k = 2$)	Low	Residual confounding by disease severity
Vaginal excision or opening	2 cohorts	OR 2.47 (1.26–4.83)	Not estimated ($k = 2$)	Very low	Exposure definitions differed
Operative duration	2 cohorts	MD +73.08 min (41.92–104.24)	Not estimated ($k = 2$)	Low	Likely reflects operative complexity
Protective stoma	3 cohorts	Crude OR 2.96 (1.67–5.27)	Not estimated ($k = 3$)	Very low	Confounding by indication; not a causal stoma effect
Anastomosis below 8 cm	1 cohort	Crude OR ≈ 9.85	Not applicable	Very low	Exploratory; few events and uncertain magnitude
Levator ani involvement	1 cohort	Crude OR ≈ 39.6	Not applicable	Very low	Exploratory marker; small exposed group
<i>C. difficile</i> infection	1 cohort	Crude OR ≈ 9.93	Not applicable	Very low	Exploratory; temporal relationship uncertain

DISCUSSION

This systematic review and meta-analysis found that author-defined anastomotic leakage, dehiscence, or related bowel or rectovaginal fistula occurs after approximately 3% of colorectal operations for deep infiltrating endometriosis. Although the average incidence was relatively low, heterogeneity was substantial ($I^2 = 70.6\%$). The 10.2% rate in the Flammang cohort accounted for much of this variation: excluding that study reduced the pooled incidence only modestly, from 3.3% to 2.9%, while reducing I^2 to 0%. This sensitivity analysis indicates that the overall incidence estimate is reasonably robust, but the higher-risk specialist-center experience should remain visible when counselling

patients. Differences in operative technique, anastomotic height, disease severity, surveillance, and outcome definitions probably contributed to the remaining clinical variation. Previous reviews have likewise reported inconsistent rates because some studies included only confirmed leakage, whereas others incorporated rectovaginal fistula within a composite outcome.^[2,3]

Segmental colorectal resection was associated with approximately fivefold higher crude odds of leakage or fistula compared with rectal shaving. This finding is consistent with previous systematic reviews showing lower postoperative morbidity after conservative rectal procedures.^[3,4] In the large CIRENDO cohort, discoid excision, segmental resection, and combined procedures were

independently associated with bowel fistula compared with shaving.^[7] However, this association should not be interpreted as proof that segmental resection is inherently inappropriate. Shaving is generally selected for smaller and more superficial lesions, whereas segmental resection is required for large, multifocal, circumferential, or stenosing disease. Consequently, confounding by disease severity and surgical selection is unavoidable. Nevertheless, bowel transection, vascular division, mesorectal dissection, and anastomotic construction introduce risks that are absent after uncomplicated shaving.

Low anastomotic height was another potential risk signal, but the magnitude of association should be interpreted cautiously because it was derived from small event counts. Anastomoses below 8 cm from the anal verge, particularly those approximately 5 cm or less from the anal verge, were associated with a greater frequency of dehiscence or fistula.^[10,11] This observation is directionally consistent with general colorectal surgery, in which distal rectal anastomosis is a recognized risk factor for leakage.^[5] Restricted pelvic access, incomplete serosal coverage of the distal rectum, impaired perfusion after extensive mobilization, and increased anastomotic tension provide plausible explanations. Exact anastomotic height should therefore be documented, while recognizing that the present endometriosis-specific estimate remains very-low-certainty evidence.

Concomitant vaginal excision or opening was also associated with increased leakage or fistula risk. Vaginal opening may increase bacterial contamination and create adjacent colorectal and vaginal suture lines. Extensive posterior vaginal dissection can further compromise tissue vascularity and eliminate the healthy tissue plane separating the two repairs. However, vaginal surgery is more frequently required in patients with severe posterior compartment disease, making it difficult to distinguish its independent effect from the effects of low anastomosis and advanced disease.^[7,11] Similarly, the large crude estimate for levator ani involvement was based on a small exposed group and few events; it should be regarded as an imprecise marker of very low, laterally extensive disease rather than an established independent causal factor.

Patients who developed leakage or fistula had substantially longer operations. Operative duration is unlikely to represent an independent causal exposure; instead, it probably reflects extensive adhesiolysis, multivisceral involvement, difficult pelvic access, concomitant urinary or vaginal surgery, and intraoperative technical problems. Nevertheless, unexpectedly prolonged surgery may identify patients who require reassessment of anastomotic perfusion and integrity and more intensive postoperative surveillance.

The crude analysis showed a higher leakage or fistula rate among patients who received protective diversion, but this reflects the preferential selection of higher-risk cases for a stoma rather than a harmful

effect of the stoma itself. Stomas were more often constructed for very low, technically difficult, or poorly perfused anastomoses and for combined colorectal and vaginal resections, producing strong confounding by indication. A diverting stoma may not prevent an anastomotic defect but may reduce fecal contamination and the severity of pelvic sepsis.^[13] Conversely, diversion carries risks of dehydration, electrolyte disturbance, obstruction, psychological burden, and complications related to reversal. Recent specialist-center evidence also suggests that diversion can facilitate endoscopic management when leakage occurs, although it should not be used routinely.^[12]

Traditional patient-related factors, including age, body mass index, smoking, previous pelvic surgery, and common comorbidities, were not consistently associated with leakage. This may reflect the relatively young and healthy endometriosis population, but inadequate statistical power cannot be excluded. Preoperative nutritional risk was associated with leakage in one prospective cohort.^[6] Nutritional screening and correction of clinically significant deficiencies are therefore reasonable before elective colorectal resection and are consistent with enhanced-recovery recommendations.^[14] Postoperative *Clostridioides difficile* infection was another potential risk factor, although its temporal relationship with dehiscence remains uncertain.^[11]

This review is limited by observational study designs, inconsistent outcome definitions, few leakage events, and residual confounding. Comparisons between procedures were particularly affected by differences in disease severity. Future prospective multicenter studies should use the International Study Group of Rectal Cancer definition and grading system, report rectovaginal fistula separately, and document anastomotic height, vaginal opening, perfusion assessment, integrity testing, diversion, nutritional status, and 30- and 90-day outcomes.^[15] Until stronger evidence is available, individualized risk assessment, multidisciplinary surgical expertise, nutritional optimization, meticulous anastomotic technique, and vigilant postoperative surveillance remain central to reducing the consequences of leakage.

CONCLUSION

Author-defined anastomotic leakage, dehiscence, or related bowel or rectovaginal fistula occurs after approximately 3% of colorectal operations for deep infiltrating endometriosis. The available evidence suggests that risk may be greater following segmental colorectal resection, low or ultralow anastomosis, concomitant vaginal excision or opening, extensive pelvic disease, and prolonged operative duration. Nutritional compromise and postoperative infection may represent additional risk signals. Several of the largest crude odds ratios, particularly for very low anastomosis and levator ani involvement, were

derived from small numbers and should be interpreted cautiously. The higher crude leakage rate among patients with protective diversion reflects confounding by indication and should not be interpreted as evidence that stoma formation causes anastomotic failure.

The certainty of evidence remains low because the available studies were observational, definitions of leakage varied, and the number of events was limited. Patients requiring complex colorectal surgery should therefore undergo individualized risk assessment and be managed in experienced multidisciplinary centers with nutritional optimization, careful operative planning, meticulous anastomotic technique, selective diversion, and vigilant postoperative surveillance. Prospective multicenter studies using standardized outcome definitions are required to validate risk factors and develop reliable prediction models.

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