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Original Article

Factors associated with advanced-stage endometriosis: A multivariable analysis

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Abstract

Endometriosis is a chronic gynecological condition with heterogeneous clinical presentations. This cross-sectional study examined factors associated with advanced-stage endometriosis among 32 women with surgically confirmed disease at Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia, between December 2024 and July 2025. Endometriosis was classified using the revised American Society for Reproductive Medicine system as minimal–mild (stages I–II) or moderate–severe (stages III–IV). Demographic, reproductive, clinical, and biomarker data (CA-125 and IL-6) were collected. Exploratory multivariable logistic regression and receiver operating characteristic (ROC) analyses were performed. Of 32 women (mean age, 34.2±6.8 years), 24 (75.0%) had stages III–IV disease. Based on the displayed frequencies, advanced-stage disease was more common among nulliparous women (17/19) and women with infertility (18/20), and among those with CA-125 ≥90.67 U/mL (20/22). In the reported adjusted model, CA-125 ≥90.67 U/mL (adjusted odds ratio (aOR): 9.87; 95% confidence interval (CI): 1.45–67.12; p=0.019) and nulliparity (aOR: 6.42; 95%CI: 1.12–36.78; p=0.037) were associated with stages III–IV disease; infertility was retained but was not statistically significant (aOR: 4.95; 95%CI: 0.89–27.54; p=0.067). Apparent discrimination was high (area under the curve: 0.892), but the small sample, data-derived CA-125 threshold, and lack of external validation limit interpretation. These preliminary associations require confirmation in larger studies before clinical implementation.

Keywords: Advanced-stage endometriosis, biomarkers, CA-125, infertility, multivariable analysis

Introduction

Endometriosis, a chronic inflammatory condition characterized by endometrial-like tissue outside the uterus, affects approximately 10–15% of women of reproductive age worldwide [1]. Clinical presentation and disease burden vary substantially, with implications for fertility, quality of life, and healthcare utilization [1,2]. The revised American Society for Reproductive Medicine (ASRM) classification describes four stages: minimal (I), mild (II), moderate (III), and severe (IV), according to the extent and location of lesions and adhesions [3]. More extensive disease may be associated with greater treatment complexity and fertility impairment, although symptom intensity does not invariably correspond to surgical stage [4,5]. Published Indonesian data remain limited, particularly for surgically characterized populations [6]. Patient-centered endometriosis care has been examined in Indonesian referral hospitals [7]. In an Aceh referral-hospital series of 61 patients undergoing endometrioma cystectomy in 2016–2018, the largest age subgroup was 30–34 years (32.78%) [8].

Since inflammation and angiogenesis are the main biological mechanisms underlying the development of endometriosis [9], understanding factors associated with advanced-stage

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endometriosis is crucial for several clinical reasons. Early identification of high-risk patients may facilitate timely referral to specialized centers, optimize surgical planning, and improve patient counseling regarding fertility preservation [10]. Additionally, risk stratification models may guide decisions regarding the timing and extent of surgical intervention, particularly in young women desiring future fertility [11].

Demographic characteristics, reproductive history, symptoms, and serum biomarkers have been investigated in relation to disease severity [12,13]. Cancer antigen 125 (CA-125) is among the most widely studied circulating biomarkers of endometriosis [14], and higher concentrations have been reported in more extensive disease [15,16]. Interleukin-6 (IL-6), an inflammatory mediator, has also been investigated as a potential biomarker [17,18]. Evidence integrating these characteristics in Indonesian surgical cohorts remains limited. This study aimed to explore factors associated with ASRM stages III–IV endometriosis among women undergoing surgery at a tertiary hospital in Banda Aceh.

Methods

Study design and participants

A cross-sectional study was conducted at Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia, between December 2024 and July 2025. The source population comprised women with suspected endometriosis scheduled for laparoscopy or laparotomy. Simple random sampling was performed using a random number generator. Eligible participants had preoperative imaging, no previous surgery for endometriosis, no hormonal therapy during the preceding three months, and planned surgical assessment. Women with histopathological findings inconsistent with endometriosis, imaging findings suggestive of malignancy, concurrent inflammatory conditions, pregnancy, or lactation were excluded. Only women with surgically confirmed endometriosis were included in the analysis.

The initial sample-size calculation was based on general statistical guidance [19]. However, the final sample included only 32 participants, of whom eight had ASRM stages I–II disease. Consequently, the number of observations in the smaller outcome group was insufficient to support a claim of adequate events per predictor for a conventional multivariable logistic regression model. The analyses should therefore be interpreted as exploratory.

Data collection

Demographic, reproductive, and clinical information was obtained through structured interviews and medical-record review. Variables included age, marital status, education, occupation, parity, body mass index, family history of endometriosis, symptom duration, dysmenorrhea, dyspareunia, chronic pelvic pain, infertility, and other presenting symptoms. Severe dysmenorrhea was defined as a visual analog scale (VAS) score ≥7. Severe dyspareunia was defined as pain leading to avoidance of sexual intercourse. Chronic pelvic pain was defined as noncyclical pelvic pain lasting more than six months, and infertility as failure to conceive after 12 months of regular unprotected intercourse.

Biomarker assessment

Venous blood samples (5 mL) were collected preoperatively. Samples were centrifuged at 3000 rpm for 15 minutes, and serum was stored at -80°C until analysis.

Serum CA-125 concentrations were measured using a chemiluminescent microparticle immunoassay on the ARCHITECT i2000SR analyzer (Abbott Diagnostics, Abbott Park, Illinois, USA), with a stated detection range of 1.0–5,000 U/mL. Serum IL-6 was measured using the Human IL-6 ELISA Kit (R&D Systems, Minneapolis, Minnesota, USA), with a stated assay range of 0.156–10 pg/mL. CA-125 was determined using a two-step sandwich immunoassay with chemiluminescent detection. IL-6 was measured using a sandwich ELISA, with optical density assessed at 450 nm and wavelength correction at 540 nm.

Surgical assessment and staging

All participants underwent laparoscopic or open surgical assessment by experienced gynecologic surgeons. Intraoperative staging followed the revised ASRM classification: stages I–II were

categorized as minimal–mild disease and stages III–IV as moderate–severe (advanced-stage) disease. Classification was based on lesion extent, adhesions, and ovarian involvement.

Statistical analysis

Continuous variables were summarized as mean±standard deviation (SD) or median (interquartile range (IQR)), according to the Shapiro–Wilk test. Categorical variables were expressed as frequencies and percentages. Group comparisons used the chi-square or Fisher's exact test for categorical variables and the independent-samples t-test or Mann–Whitney U test for continuous variables, as appropriate. Crude odds ratios (ORs) and approximate 95% confidence intervals (CIs) were calculated from the 2×2 frequencies, with two-sided Fisher's exact p-values. Exploratory multivariable logistic regression was used to assess adjusted associations. Model discrimination was assessed using receiver operating characteristic (ROC) analysis and the area under the curve (AUC). The Hosmer–Lemeshow test was specified for model calibration, and bootstrap resampling was used for internal validation. Statistical significance was defined as $p<0.05$. Analyses were performed using SPSS version 28.0 (IBM Corporation, Armonk, NY, USA).

Results

Participants' characteristics

A total of 32 women with surgically confirmed endometriosis were included, and their characteristics, clinical symptoms, and biomarker levels are presented in **Table 1**. Of these, 24 (75.0%) had advanced-stage endometriosis (stages III–IV), and eight (25.0%) had minimal-to-mild disease (stages I–II). The mean age was 34.2±6.8 years, with 12 participants (37.5%) aged ≥35 years, and most participants were married (87.5%). The mean body mass index was 23.4±3.2 kg/m². Nulliparity was reported in 19 participants (59.4%), infertility in 20 (62.5%), and a family history of endometriosis in six (18.8%). Dysmenorrhea was the most frequently reported symptom (96.9%), followed by chronic pelvic pain (75.0%) and dyspareunia (68.8%).

Compared with participants with minimal-to-mild disease, those with advanced-stage endometriosis had higher proportions of women aged ≥35 years (45.8% vs 12.5%), nulliparity (70.8% vs 25.0%), infertility (75.0% vs 25.0%), and dyspareunia (79.2% vs 37.5%) (**Table 1**).

Table 1. Demographic characteristics, clinical symptoms, and biomarker levels by ASRM endometriosis stage

Variables	Total (n=32)	Minimal–mild (n=8)	Advanced (n=24)
Age, years (mean±SD)	34.2±6.8	31.5±5.2	35.1±7.2
Age ≥35 years, n (%)	12 (37.5)	1 (12.5)	11 (45.8)
Married, n (%)	28 (87.5)	7 (87.5)	21 (87.5)
Body mass index (BMI), kg/m² (mean±SD)	23.4±3.2	23.8±2.9	23.2±3.4
Nulliparity, n (%)	19 (59.4)	2 (25.0)	17 (70.8)
Infertility, n (%)	20 (62.5)	2 (25.0)	18 (75.0)
Family history of endometriosis, n (%)	6 (18.8)	0 (0.0)	6 (25.0)
Dysmenorrhea, n (%)	31 (96.9)	8 (100.0)	23 (95.8)
Dyspareunia, n (%)	22 (68.8)	3 (37.5)	19 (79.2)
Chronic pelvic pain, n (%)	24 (75.0)	5 (62.5)	19 (79.2)
CA-125, U/mL (mean±SD)	99.6±69.9	52.3±28.1	115.4±72.8
CA-125 ≥90.67 U/mL, n (%)	22 (68.8)	2 (25.0)	20 (83.3)
IL-6, pg/mL (median, IQR)	6.8 (4.2–11.3)	5.1 (3.2–8.9)	7.9 (4.8–12.1)

CA-125: cancer antigen 125; IL-6: interleukin-6; IQR: interquartile range; SD: standard deviation

Biomarker analysis

Serum CA-125 concentrations ranged from 18.5 to 285.4 U/mL, with a recalculated overall mean of approximately 99.6±69.9 U/mL based on the subgroup data presented in **Table 1**. ROC analysis identified a study-derived cutoff of 90.67 U/mL for distinguishing stages III–IV from stages I–II disease (AUC: 0.812; 95%CI: 0.654–0.971; $p=0.004$). At this cutoff, the **Table 1** frequencies corresponded to 83.3% sensitivity (20/24) and 75.0% specificity (6/8).

At the CA-125 threshold of ≥90.67 U/mL, 20 of 22 participants (90.9%) had stages III–IV disease, compared with 4 of 10 participants (40.0%) below the threshold. The corresponding Fisher's exact *p*-value was 0.005.

IL-6 concentrations ranged from 1.2 to 18.7 pg/mL (median: 6.8 pg/mL; IQR: 4.2–11.3). Median concentrations were 7.9 pg/mL in stages III–IV and 5.1 pg/mL in stages I–II, with a reported between-group *p*=0.089.

Surgical findings and disease staging

Surgical approach, ASRM stage, and anatomical distribution of endometriosis are summarized in **Table 2**. Laparoscopy was performed in 28 women (87.5%), and 24 (75.0%) had stages III–IV disease. Deep infiltrating endometriosis was documented in 20 women (62.5%), and extensive pelvic adhesions in 22 (68.8%).

Table 2. Surgical approach, ASRM stage, and anatomical distribution of endometriosis among study participants

Category	Subcategory	n/N	Percentage
Surgical approach	Laparoscopic evaluation	28/32	87.5
	Laparotomy (suspected extensive disease/prior surgery)	4/32	12.5
ASRM stage	Stage I	4/32	12.5
	Stage II	4/32	12.5
	Stage III	12/32	37.5
	Stage IV	12/32	37.5
	Subtotal: Stages I–II (minimal–mild)	8/32	25.0
	Subtotal: Stages III–IV (advanced)	24/32	75.0
Anatomical distribution	Ovarian involvement	27/32	84.4
	Bilateral ovarian endometriomas	18/32	56.3
Deep infiltrating endometriosis (DIE)	Any DIE	20/32	62.5
	Rectovaginal septum	14/32	43.8
	Uterosacral ligaments	12/32	37.5
	Rectosigmoid colon	6/32	18.8
Adhesions	Extensive pelvic adhesions	22/32	68.8
	Complete obliteration of pouch of Douglas	14/32	43.8
Other organ involvement	Bowel involvement (specialist consult)	8/32	25.0
	Urological involvement	4/32	12.5

Bivariate analysis of factors associated with advanced endometriosis

Unadjusted associations with advanced endometriosis are presented in **Table 3**. Nulliparity (crude OR: 7.29; 95%CI: 1.17–45.25; Fisher's exact *p*=0.038), infertility (OR: 9.00; 95%CI: 1.42–57.12; *p*=0.030), and CA-125 ≥90.67 U/mL (OR: 15.00; 95%CI: 2.18–103.04; *p*=0.005) were associated with stages III–IV disease. Age ≥35 years (*p*=0.204), dyspareunia (*p*=0.072), and family history of endometriosis (*p*=0.296) were not statistically significant by Fisher's exact test. The crude OR for family history was not estimable because of a zero cell.

Multivariate analysis and predictive modeling

The exploratory multivariable logistic regression analysis considered age ≥35 years, nulliparity, infertility, dyspareunia, CA-125 ≥90.67 U/mL, and family history (**Table 3**). The final model contained CA-125 ≥90.67 U/mL, nulliparity, and infertility. The multivariable model yielded adjusted associations for CA-125 ≥90.67 U/mL (aOR: 9.87; 95%CI: 1.45–67.12; *p*=0.019) and nulliparity (aOR: 6.42; 95%CI: 1.12–36.78; *p*=0.037). Infertility was retained but was not statistically significant (aOR: 4.95; 95%CI: 0.89–27.54; *p*=0.067). All adjusted estimates were imprecise, as indicated by their wide confidence intervals (**Table 3**).

Table 3. Unadjusted and exploratory multivariable logistic regression analyses of factors associated with advanced-stage endometriosis

Variables	Crude OR (95%CI)	Fisher *p*-value	Multivariable aOR (95%CI)	*p*-value
Age ≥35 years	5.92 (0.63–55.85)	0.204	–	–
Nulliparity	7.29 (1.17–45.25)	0.038	6.42 (1.12–36.78)	0.037
Infertility	9.00 (1.42–57.12)	0.030	4.95 (0.89–27.54)	0.067

Variables	Crude OR (95%CI)	Fisher *p*-value	Multivariable aOR (95%CI)	*p*-value
Dyspareunia	6.33 (1.11–36.00)	0.072	–	–
CA-125 ≥90.67 U/mL	15.00 (2.18–103.04)	0.005	9.87 (1.45–67.12)	0.019
Family history	Not estimable (zero cell)	0.296	–	–

aOR: adjusted odds ratio; CA-125: cancer antigen 125; CI: confidence interval; OR: odds ratio

Model performance and validation

The three-variable model showed an apparent AUC of 0.892 (95%CI: 0.780–1.000; $p<0.001$), with reported sensitivity of 91.7% and specificity of 75.0%. Model calibration was assessed using the Hosmer–Lemeshow test. These apparent performance estimates require cautious interpretation because the model was evaluated using a small development sample.

Bootstrap resampling with 1,000 replicates produced a reported bias-corrected AUC of 0.876 (95%CI: 0.745–0.987). Optimism may remain if predictor selection and the data-derived CA-125 cutoff were not repeated within resampling.

An exploratory three-factor score assigned 3 points for CA-125 ≥90.67 U/mL, 2 points for nulliparity, and 2 points for infertility (range: 0–7). A score ≥5 reportedly yielded 83.3% sensitivity and 87.5% specificity in this cohort. The scoring weights and thresholds require justification, and external validation is needed before clinical use.

Exploratory subgroup comparisons were also reported. Owing to the small subgroup sizes, these findings cannot establish generalizability and need replication in independent populations.

Discussion

In this cross-sectional surgical cohort, CA-125 ≥90.67 U/mL and nulliparity were associated with stages III–IV endometriosis in the adjusted model, whereas infertility was retained without reaching conventional statistical significance. The model's apparent discrimination was high (AUC: 0.892), but its estimates are uncertain and require verification and independent validation.

Three-quarters of participants had advanced-stage disease, a pattern that may reflect referral and surgical selection at a tertiary center rather than population prevalence. Indonesian work on patient-centered endometriosis care provides relevant context [7], but diagnostic delay or disease progression cannot be inferred from this cross-sectional sample.

Serum CA-125 concentrations were higher among women with stages III–IV disease, consistent with previous literature describing an association between CA-125 and endometriosis severity [20,21,22]. The observed threshold of 90.67 U/mL was selected within this cohort and should not be interpreted as a validated clinical cutoff. Elevated CA-125 may reflect a combination of endometriotic tissue burden, ovarian endometriomas, and inflammatory or mesothelial responses [23,24]. These potential mechanisms were not directly measured in the present study. The data-derived 90.67 U/mL threshold differs from the conventional 35 U/mL value sometimes used in other gynecologic contexts. Previous research has evaluated CA-125 in endometriosis, but the cited studies should be reviewed to substantiate specific severity-related thresholds [25,26].

Nulliparity was also associated with advanced-stage disease in the reported adjusted analysis, although the direction and timing of this relationship cannot be determined. Menstrual and pregnancy-related hormonal exposures have been proposed as biological explanations, but causal inferences are not justified by these data [27,28]. Infertility was associated with advanced-stage disease in the unadjusted comparison but not in the originally reported adjusted model (aOR: 4.95; 95%CI: 0.89–27.54; $p=0.067$). Endometriosis-associated anatomical changes, ovarian involvement, inflammation, and impaired ovarian function may contribute to infertility [29,30]. In this study, infertility may also represent a consequence, rather than a cause, of extensive disease.

The associations observed here may inform future research on preoperative risk assessment and patient counseling. However, the proposed regression model and three-factor score should not guide referral or surgical management without independent evaluation. A clinically useful model would require prespecified predictors, a reproducible threshold, robust calibration, and evaluation in larger independent cohorts that include the intended preoperative patient

population. Its diagnostic value cannot be established from women selected solely on the basis of surgically confirmed endometriosis.

Some limitations should be emphasized. The cross-sectional design precludes assessment of temporality or causation. The sample comprised only 32 surgically confirmed cases at one referral hospital, including eight women with stages I–II disease, making the multivariable estimates imprecise and vulnerable to overfitting. The CA-125 cutoff and model performance were assessed within the development dataset, increasing optimism; neither the model nor the score has been externally validated. Selection bias, incomplete description of recruitment and model construction, and uncertainty regarding IL-6 quantification further limit interpretation. Larger, multicenter studies with prespecified analyses and external validation are needed.

Conclusion

In this exploratory cohort, CA-125 ≥90.67 U/mL and nulliparity were associated with stages III–IV endometriosis after adjustment, whereas infertility was not statistically significant. Although the model showed high apparent discrimination, its performance may be overestimated because of the small single-center sample and data-derived threshold. Confirmation of the statistical results and validation in larger, independent preoperative cohorts are required before these findings can inform clinical risk assessment or management.

Ethics approval

The study protocol was approved by the Ethics Committee of Dr. Zainoel Abidin Hospital, Banda Aceh (approval number: 131/ETIK-RSUDZA/2025). All participants provided written informed consent before enrollment. Confidentiality was maintained, and study procedures followed the Declaration of Helsinki.

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None.

Competing interests

All authors declare that they have no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

Claude was used for language editing to improve grammar, sentence structure, and readability. The authors confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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