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Article

Clinical Outcomes of Uterine Artery Embolization in Adenomyosis With and Without Coexisting Uterine Fibroids or Ovarian Endometrioma: A Retrospective Clinical Analysis

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Abstract

Aims/Background: Uterine artery embolization (UAE) is a minimally invasive therapeutic option for adenomyosis (AM). However, its clinical effectiveness in patients with comorbid gynecologic disorders remains unclear. This study aimed to evaluate the clinical efficacy of UAE in AM patients with or without concomitant uterine fibroids (UFs) or ovarian endometrioma (OE). **Methods**: A total of 243 women with AM who underwent UAE were retrospectively enrolled, including 141 patients with AM alone, 71 with concomitant UFs, and 31 with concomitant OE. Based on clinical response, 193 patients were classified as having effective treatment outcomes and 50 as ineffective. Baseline demographic and clinical characteristics were recorded. Symptom severity scale (SSS), health-related quality of life (HRQOL), and numerical rating scale (NRS) scores were assessed preoperatively, at 3 months after UAE, and at the last follow-up. **Results**: Significant differences in baseline age and cancer antigen 125 (CA125) levels were observed among the three groups ($p < 0.05$). Postoperatively, all groups showed significant reductions in SSS and NRS scores, as well as significant improvements in HRQOL scores, at both 3 months and the end of follow-up compared with baseline (all $p < 0.001$). At the final follow-up, patients in the AM + OE group exhibited significantly higher SSS and NRS scores as well as significantly lower HRQOL scores compared with the other two groups ($p < 0.05$). In contrast, no significant differences were observed between the simple AM and AM + UFs groups. Patients in the effective group were significantly older, had higher parity, lower CA125 levels, and showed a higher incidence of concomitant UFs but a lower incidence of OE compared with the ineffective group (all $p < 0.05$). HRQOL scores were significantly higher, and NRS scores were significantly lower in the effective group than in the ineffective group at both postoperative time points (all $p < 0.001$). The overall clinical efficacy rate was 79.42%, with no significant difference between the simple AM and AM + UFs groups (80.85% vs 88.73%, $p_a = 0.15$). However, the clinical efficacy rate was significantly lower in the AM + OE group (51.61%) than in both the simple AM (80.85%, $p = 0.001$) and AM + UFs (88.73%, $p < 0.001$) groups. Kaplan-Meier analysis indicated that concomitant OE was associated with an increased risk of treatment failure following UAE. **Conclusion**: UAE effectively alleviates symptoms and improves quality of life in patients with AM, particularly in those with isolated AM or concomitant UFs. However, clinical outcomes are less favorable in patients with concomitant OE, suggesting the need for individualized therapeutic strategies in this subgroup.

Keywords: adenomyosis; uterine artery embolization; leiomyoma; endometrioma; quality of life

1. Introduction

Adenomyosis (AM) is generally defined as a benign gynecological disorder characterized by ectopic endometrial tissue invasion into the myometrium [1]. The clinical manifestations of AM include abnormal uterine bleeding (irregular, heavy, or intermenstrual bleeding), pelvic pain, dysmenorrhea, and dyspareunia [2]. Although AM was historically considered to predominantly affect multiparous individuals presenting with dysmenorrhea and menorrhagia, it is now increasingly diagnosed in younger patients, including those experiencing infertility or subfertility [3]. Moreover, AM commonly coexists with other gynecological conditions, particularly endometriosis and uterine fibroids (UFs), which complicates the attribution of clinical symptoms solely to the adenomyotic process [4]. Additional diagnostic challenges emerge from the lack of universally accepted diagnostic criteria for AM [5]. Therefore, the management of AM remains complex and encompasses surgical, medical, and radiological interventions [6]. However, effective treatment strategies with durable symptom control and minimal side effects remain limited.

Ovarian endometrioma (OE), commonly referred to as "chocolate cysts", is an ovarian cystic lesion resulting from endometriosis, a prevalent gynecological disorder characterized by the growth of endometrial tissue outside the uterus. This condition is associated with clinical symptoms, including pelvic pain, dysmenorrhea, and infertility [7]. The presence of OE in AM patients may be associated with more severe uterine dysfunction and symptom burden [8]. UFs, the most prevalent benign tumors affecting women globally, represent a significant health burden, with an estimated prevalence of up to 80% among premenopausal women, and are frequently associated with pain, heavy menstrual bleeding, and infertility [9]. Imaging studies by Neal M. Lonky et al. [10] have demonstrated that two-dimensional ultrasound exhibits limited sensitivity for detecting AM when the uterus is concurrently affected by UFs. However, the impact of the different comorbidities on clinical outcomes in patients with AM has been insufficiently explored.

Uterine artery embolization (UAE) is a minimally invasive procedure that has been widely recognized for the management of symptomatic UFs and has also demonstrated efficacy in the treatment of symptomatic AM [11]. Growing evidence suggests that UAE does not adversely affect fertility potential, or menstrual resumption [12,13]. In recent years, its favorable safety profile and therapeutic effectiveness have contributed to increasing clinical acceptance of UAE [14]. The clinical benefits of UAE in AM have been well documented, particularly in alleviating dysmenorrhea and improving quality of life (QOL) [15]. However, endometriosis has been identified as a potential negative prognostic factor for UAE, as patients with coexisting AM and endometriosis are more likely to experience incomplete lesion necrosis following embolization [16]. Despite these observations, comparative data on UAE outcomes among AM patients with different gynecological comorbidities remain limited. Therefore, this study aimed to evaluate the therapeutic efficacy of UAE and to compare clinical outcomes in AM patients with varying comorbid conditions, thereby providing evidence to support more individualized and optimized treatment strategies.

2. Methods

2.1 Study Subjects

From May 2017 to March 2022, 273 patients with adenomyosis (AM) who underwent uterine artery embolization (UAE) were retrospectively screened. According to the inclusion and exclusion criteria, 30 patients were excluded, and 243 eligible patients were finally enrolled in this study. The enrolled patients were divided into three groups: 141 with AM alone (simple adenomyosis), 71 with AM combined with uterine fibroids (UFs), and 31 with AM combined with ovarian endometrioma (OE) (Fig. 1). Complete clinical and follow-up data were available for all included patients. This retrospective study was performed at The Affiliated Guangdong Second Provincial General Hospital of Jinan University.

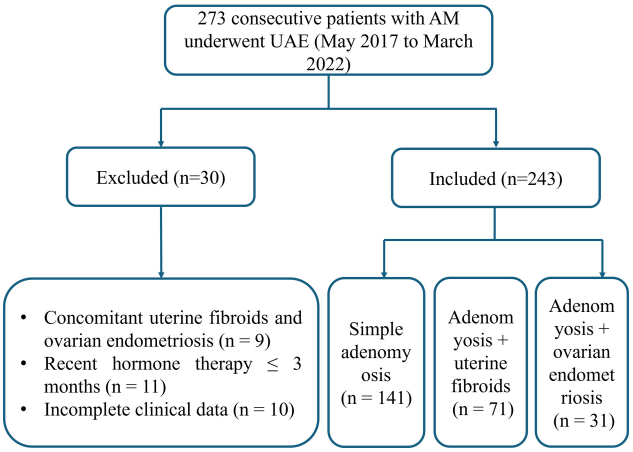

Fig. 1. Flowchart illustrating patient screening, exclusion, enrollment, and group allocation. AM, adenomyosis; UAE, uterine artery embolization.

2.2 Inclusion and Exclusion Criteria

Inclusion criteria: (1) age ≥18 years; (2) a definitive diagnosis of AM; (3) receipt of UAE treatment; and (4) women with a desire for uterine preservation and no future fertility requirements.

Exclusion criteria: (1) concomitant uterine fibroids and ovarian endometrioma; (2) recent use of hormonal agents, including oral contraceptives or progestins, within the past three months; (3) incomplete clinical data.

2.3 Diagnostic Criteria

The diagnostic criteria for AM were defined as follows [17]: all patients were diagnosed with adenomyosis based on clinical history, symptomatology, and magnetic resonance imaging (MRI) results. Clinical history and symptoms included dysmenorrhea, menorrhagia, pelvic pain, and dyspareunia, with dysmenorrhea and menorrhagia representing the predominant complaints in this cohort. MRI diagnostic criteria for adenomyosis [18] included a maximum junctional zone thickness >12 mm and the presence of high-intensity signals within the myometrium.

The diagnostic criteria for OE were as follows [19]: (i) diagnosis of OE based on MRI findings, with definitive diagnosis established when lesion consisted of multiple cysts showing uniformly high signal intensity on T1-weighted imaging (T1WI), regardless of signal intensity on T2-weighted imaging (T2WI), or when a cyst with high signal intensity on T1WI demonstrated low signal intensity on T2WI, often interspersed with areas of high signal; (ii) a maximum diameter of ovarian endometrioma ≤4 cm, indicating no indication for surgical intervention [20]; and (iii) localization of endometriosis confined to the ovary.

The diagnostic criteria for UFs were defined as follows [21]: (1) essential criterion: transvaginal ultrasound confirmation of $\geq$1 solid mass within the myometrium; (2) typical imaging and physical findings, including increased uterine volume and abnormal uterine morphology, with a firm mass of palpable on examination; and (3) associated symptoms of pelvic compression, including urinary or defecatory dysfunction and lumbosacral pain.

2.4 Surgical Approach

Patients were placed in the supine position, and routine disinfection was performed at the right femoral artery puncture site. Local anesthesia was administered using 2% lidocaine (0.1 g: 5 mL, Hualu Pharmaceutical Co., Ltd., Liaocheng, China). Under digital subtraction angiography guidance, arterial puncture was performed using the Seldinger technique, followed by insertion of a 5-F vascular sheath. A catheter was then selectively advanced into the left uterine artery. Embolization microspheres (300–500 µm; Hengrui Medical Technology Co., Ltd., Suzhou, China) were used as embolic agents and delivered through the catheter until the distal branches of the artery were no longer visualized. The same procedure was subsequently performed for embolization of the contralateral uterine artery. After catheter removal, hemostasis was achieved by manual compression of the puncture site for 10–15 minutes, followed by application of a pressure dressing with an elastic bandage. Patients were then transferred back to the ward for postoperative observation.

2.5 Data Collection

Baseline clinical indicators were extracted from electronic medical records, including age, gravidity, parity, uterine volume, duration of dysmenorrhea, hemoglobin levels, cancer antigen 125 (CA125) levels, and follow-up duration. Numerical rating scale (NRS), symptom severity scale (SSS), and health-related quality of life (HRQOL) scores were recorded preoperatively, at 3 months postoperatively, and at the final follow-up.

Uterine volume was measured and calculated using the ellipsoid formula [22]: uterine volume = D1 $\times$ D2 $\times$ D3 $\times$ π/6, where D1, D2, and D3 represent the longitudinal, transverse, and anteroposterior diameters of the uterus, respectively.

The NRS score is recognized by the American Pain Society as a standard tool for pain assessment [23]. It consists of 11 numerical levels ranging from 0 to 10, with 0 representing no pain and 10 indicating the most severe, intolerable pain. In this study, the NRS score was used to assess the subjective severity of menstrual pain experienced by patients.

The Uterine Fibroid Symptom and Quality of Life (UFS-QOL) questionnaire comprises two domains: the SSS scale and HRQOL scale [24], with a total of 37 items, including 8 symptom items and 29 HRQOL items. The questionnaire was self-administered. Symptom items evaluate the frequency and severity of disease-related symptoms, while the HRQOL items assess multiple domains of well-being, including fatigue, sleep, self-image, emotional distress/psychological burden, fear of embarrassment, interference with daily activities, social relationships, and sexual function. All items are rated on a five-point Likert scale. Symptom frequency and HRQOL items range from "never" to "always", whereas symptom severity ranges from "not at all" to "a large extent". The HRQOL total score is calculated by summing the subscale scores, excluding the symptom subscale. For HRQOL and its subscales, higher scores indicate better QOL, whereas higher SSS scores reflect greater symptom severity. Both SSS and HRQOL scores are standardized on a 0–100 scale.

All questionnaire assessments (NRS and UFS-QOL) were conducted face-to-face by trained gynecologic nurses with more than three years of clinical experience. All evaluators received standardized training in questionnaire administration and scoring procedures before study initiation. The same evaluation team conducted follow-up assessments throughout the study to ensure inter-rater consistency and data reliability. When assistance was required (e.g., for comprehension of questionnaire items), standardized and neutral explanations were provided without influencing patient responses.

2.6 Follow-Up

Follow-up data were collected through review of electronic medical records, outpatient and inpatient records, and supplemented by telephone interviews. Starting from 3 months post-surgery, SSS scores were obtained at 3-month intervals. Follow-up was terminated once the treatment was deemed ineffective. Patients who achieved effective treatment outcomes were followed for up to 36 months post-surgery.

2.7 Efficacy Evaluation

Clinical efficacy was evaluated according to predefined criteria. Treatment was classified as effective when the SSS remission rate exceeded 50%; otherwise, treatment was classified as ineffective. The SSS remission rate was calculated using the following formula: (SSS score before treatment – SSS score after treatment) / SSS score before treatment $\times$ 100%. In addition, patients who required subsequent treatments after UAE, including hysterectomy, levonorgestrel-releasing intrauterine system (Mirena), endometrial ablation, or dienogest therapy, were classified as having ineffective outcomes, even when the calculated symptom remission rate exceeded 50%.

2.8 Statistical Analysis

Statistical analyses and graphical presentations were performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism 6.0 software (GraphPad

Software Inc., San Diego, CA, USA). The Kolmogorov-Smirnov test was used to evaluate the normality of data distributions. Homogeneity of variances was assessed using Levene's test or the Brown-Forsythe test, as appropriate. Normally distributed continuous variables were expressed as mean ± standard deviation (SD). Comparisons between two groups were conducted using the independent samples *t*-test, while comparisons among multiple groups were implemented using one-way analysis of variance (ANOVA), followed by Tukey's multiple-comparisons test. Non-normally distributed continuous variables are presented as median (Q1, Q3) [interquartile range (IQR)], and comparisons between two groups were performed using the Mann-Whitney U test. For comparisons among multiple groups with non-normally distributed data, the Kruskal-Wallis test was used, followed by Dunn's post hoc test with false discovery rate (FDR) correction for multiple comparisons.

For within-group longitudinal comparisons across time points (preoperative, 3 months postoperatively, and final follow-up), the Friedman test (χ^2) was used, followed by Dunn's post hoc test. Categorical variables are presented as frequencies and percentages, and intergroup comparisons were performed using the chi-square test.

To identify independent factors associated with treatment efficacy, logistic regression analyses were performed. Univariate logistic regression was first performed to assess associations between preoperative baseline variables and clinical outcomes (effective vs ineffective). Variables with $p < 0.05$ in univariate analyses were subsequently included in a multivariate logistic regression model to adjust for potential confounding factors. Variance inflation factors (VIFs) were calculated for each independent variable to assess multicollinearity, with VIF <5 indicating the absence of significant multicollinearity. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported to quantify the strength of associations. A two-tailed $p < 0.05$ was considered statistically significant.

The Kaplan-Meier method was used to evaluate the effect of UAE on clinical efficacy in patients with AM, and differences between groups were assessed using the log-rank test. Post-hoc power analyses for subgroup comparisons were performed using Cohen's *h* and the normal approximation (two-sided $\alpha = 0.05$). Observed response rates and sample sizes were used to estimate statistical power for comparisons involving the AM + OE subgroup.

3. Results

3.1 Analysis and Comparisons of Baseline Clinical Data

Comparative analyses of baseline clinical characteristics among the three groups are presented in Table 1. Significant differences were observed in age (F = 15.06, $p < 0.001$) and CA125 levels (H = 7.04, $p = 0.03$) across the three groups. Post hoc analyses revealed that patients in the AM + UFs group were significantly older than those in the simple AM group and the AM + OE group ($p_a < 0.001$, $p_c < 0.001$), while no significant difference was observed between the simple AM and the AM + OE groups ($p_b = 0.975$). In terms of CA125 levels, the AM + OE group exhibited significantly higher levels than the AM + UFs group ($p_c = 0.003$). No significant differences were observed between the simple AM and the AM + UFs groups ($p_a = 0.11$) or between the simple AM and AM + OE groups ($p_b = 0.11$).

The median follow-up duration was 29.80 months (IQR: 23.03, 33.93) in the simple AM group, 27.03 months (IQR: 23.77, 32.38) in the AM + UFs group, and 35.77 months (IQR: 25.17, 36.00) in the AM + OE group (H = 6.20, $p = 0.05$). Follow-up duration in the AM + OE group was significantly longer than that of the simple AM ($p_b = 0.03$) and AM + UFs groups ($p_c = 0.02$). In contrast, no significant differences were identified among the three groups in terms of gravidity, parity, uterine volume, duration of dysmenorrhea, or hemoglobin levels (all $p > 0.05$).

3.2 Effect of UAE on SSS Score in Patients With AM

Changes in SSS scores among the three AM groups were evaluated at baseline, 3 months postoperatively, and at the final follow-up (Table 2). Preoperatively, no significant differences in SSS scores were observed among the three groups (H = 3.25, $p = 0.197$; all p_a, p_b, $p_c > 0.05$). At 3 months postoperatively, SSS scores decreased markedly in all groups compared with preoperative values (all $p < 0.001$). However, no significant intergroup differences were observed at this time point (H = 3.43, $p = 0.18$; all p_a, p_b, $p_c > 0.05$).

At the final follow-up, SSS scores further reduced in all groups compared with preoperative values (all $p < 0.001$). Notably, patients in the AM + OE group demonstrated significantly higher SSS scores than those in the simple AM group ($p_b = 0.01$) and the AM + UFs group ($p_c = 0.003$), while no significant difference was observed between the simple AM and AM + UFs groups ($p_a = 0.30$). No significant changes in SSS scores were observed between 3 months postoperatively and the final follow-up in either the simple AM group or the AM + OE group ($p > 0.05$). For within-group changes from 3 months to final follow-up, only the AM+UFs group showed a significant further reduction ($p = 0.020$), while no changes were seen in the simple AM ($p = 0.153$) or AM+OE ($p = 0.760$) groups.

3.3 Effect of UAE on HRQOL Scores in Patients With AM

Changes in HRQOL scores among the three groups are summarized in Table 3. Preoperatively, no significant differences were observed among the groups (H = 0.69, $p = 0.708$; $p_a = 0.94$, $p_b = 0.46$, $p_c = 0.40$). At 3 months postoperatively, HRQOL scores increased markedly in all groups compared with preoperative values (all $p < 0.001$), while intergroup differences remained non-significant (H = 4.01, $p = 0.135$; $p_a = 0.61$, $p_b = 0.07$, $p_c = 0.06$). At the final follow-up, HRQOL scores were further increased in all groups compared with preoperative values (all $p < 0.001$).

Table 1. Comparisons of general clinical baseline data.

Clinical indicators	Simple AM group (n = 141)	AM + UFs group (n = 71)	AM + OE group (n = 31)	Statistic	p	p_a	p_b	p_c
Age (years)	39.39 ± 4.88	43.08 ± 4.60	39.42 ± 4.60	F = 15.06	<0.001	<0.001	0.975	<0.001
Gravidity	3.00 (2.00, 4.00)	3.00 (1.00, 4.00)	3.00 (2.00, 3.50)	H = 1.34	0.51	0.34	0.38	0.92
Parity	2.00 (1.00, 2.00)	1.00 (1.00, 2.00)	1.00 (1.00, 2.00)	H = 3.83	0.15	0.08	0.21	0.90
Uterine volume (cm^3)	250.40 (183.10, 365.10)	276.60 (201.75, 361.90)	307.60 (231.40, 381.00)	H = 2.98	0.23	0.27	0.13	0.43
Duration of dysmenorrhea (years)	3.00 (2.00, 6.00)	4.00 (1.50, 6.00)	5.00 (2.00, 7.50)	H = 2.44	0.30	0.89	0.12	0.20
Hemoglobin (g/L)	101.00 (80.00, 121.00)	104.00 (85.00, 125.00)	108.00 (87.00, 127.50)	H = 2.19	0.34	0.22	0.27	0.79
CA125 (U/mL)	72.10 (41.45, 132.42)	65.35 (33.51, 103.79)	94.38 (49.86, 199.87)	H = 7.04	0.03	0.11	0.11	0.003
Follow-up duration	29.80 (23.03, 33.93)	27.03 (23.77, 32.38)	35.77 (25.17, 36.00)	H = 6.20	0.05	0.61	0.03	0.02

Note: CA125, cancer antigen 125; UFs, uterine fibroids; OE, ovarian endometrioma. Measurement data with normal distribution were expressed as mean ± standard deviation (SD). One-way analysis of variance (ANOVA) was used for multi-group data comparisons. The Tukey's multiple comparison test was used for post hoc tests. Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Kruskal-Wallis H test was used for comparisons among multiple groups, followed by the Dunn's post hoc test. The p_a represented AM + UFs group vs Simple AM group; The p_b represented AM + OE group vs Simple AM group; p_c represented AM + OE group vs AM + UFs group. The $p < 0.05$ indicated a statistically significant difference.

Table 2. Changes in SSS scores of the three groups and comparisons between groups.

Clinical indicators	Simple AM group (n = 141)	AM + UFs group (n = 71)	AM + OE group (n = 31)	Statistic	p	p_a	p_b	p_c
Pre-operation	53.13 (37.50, 62.50)	50.00 (40.63, 70.31)	43.75 (28.13, 59.38)	H = 3.25	0.197	0.70	0.11	0.08
3 months postoperatively	12.50 (3.13, 18.75)	9.38 (6.25, 18.75)	15.63 (9.38, 25.00)	H = 3.43	0.18	0.93	0.08	0.09
At the end of follow-up	9.38 (0.00, 15.63)	6.25 (0.00, 15.63)	15.63 (6.25, 31.26)	H = 8.84	0.012	0.30	0.01	0.003
Within-group comparisons	$\chi^2 = 194.01, p < 0.001$	$\chi^2 = 89.60, p < 0.001$	$\chi^2 = 20.94, p < 0.001$					
3 months vs pre-operation	<0.001	<0.001	<0.001					
End vs pre-operation	<0.001	<0.001	<0.001					
End vs 3 months	0.153	0.020	0.760					

Note: SSS, symptom severity scale. Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Kruskal-Wallis H test was used for comparisons among multiple groups, followed by the Dunn's post hoc test. For within-group longitudinal comparisons across different time points (pre-operation, 3 months postoperatively, and at the end of follow-up), the Friedman test (χ^2) was used, followed by the post hoc Dunn's test. p_a represented AM + UFs group vs Simple AM group; p_b represented AM + OE group vs Simple AM group; p_c represented AM + OE group vs AM + UFs group.

Table 3. Changes in the HRQOL score of the three groups and comparisons between groups.

Clinical indicators	Simple AM group (n = 141)	AM + UFs group (n = 71)	AM + OE group (n = 31)	Statistic	p	p_a	p_b	p_c
Pre-operation	43.97 (28.45, 61.21)	46.55 (27.16, 59.48)	40.52 (28.45, 48.71)	H = 0.69	0.708	0.94	0.46	0.40
3 months postoperatively	80.17 (69.83, 93.97)	84.48 (67.25, 93.97)	71.55 (59.48, 87.93)	H = 4.01	0.135	0.61	0.07	0.06
At the end of follow-up	91.38 (81.03, 97.41)	91.38 (82.33, 96.98)	74.14 (53.88, 90.09)	H = 14.34	<0.001	0.52	<0.001	<0.001
Within-group comparisons	χ^2 =176.67, $p < 0.001$	χ^2 = 91.68, $p < 0.001$	χ^2 =17.61, $p < 0.001$					
3 months vs pre-operation	<0.001	<0.001	<0.001					
End vs pre-operation	<0.001	<0.001	<0.001					
End vs 3 months	<0.001	<0.001	0.799					

Note: HRQOL, health-related quality of life. Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Kruskal-Wallis H test was used for comparisons among multiple groups, followed by Dunn's post hoc test. For within-group longitudinal comparisons across different time points (pre-operation, 3 months postoperatively, and at the end of follow-up), the Friedman test (χ^2) was used, followed by the post hoc Dunn's test. The p_a represented AM + UFs group vs Simple AM group; p_b represented AM + OE group vs Simple AM group; p_c represented AM + OE group vs AM + UFs group.

Table 4. Changes in NRS scores of the three groups and comparisons between groups.

Clinical indicators	Simple AM group (n = 141)	AM + UFs group (n = 71)	AM + OE group (n = 31)	Statistic	p	p_a	p_b	p_c
Pre-operation	6.00 (4.00, 9.00)	5.00 (3.00, 8.50)	6.00 (4.00, 10.00)	H = 4.13	0.127	0.05	0.79	0.26
3 months postoperatively	1.00 (0.00, 2.00)	1.00 (0.00, 2.00)	1.00 (0.00, 3.00)	H = 1.37	0.504	0.95	0.24	0.34
At the end of follow-up	0.00 (0.00, 2.00)	0.00 (0.00, 1.00)	1.00 (0.00, 3.50)	H = 7.68	0.021	0.26	0.02	0.003
Within-group comparisons	χ^2 = 198.19, $p < 0.001$	χ^2 = 84.56, $p < 0.001$	χ^2 = 27.74, $p < 0.001$					
3 months vs pre-operation	<0.001	<0.001	<0.001					
End vs pre-operation	<0.001	<0.001	<0.001					
End vs 3 months	0.821	0.068	0.432					

Note: NRS, numerical rating scale. Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Kruskal-Wallis H test was used for comparisons among multiple groups, followed by Dunn's post hoc test. For within-group longitudinal comparisons across different time points (pre-operation, 3 months postoperatively, and at the end of follow-up), the Friedman test (χ^2) was used, followed by the post hoc Dunn's test. The p_a represented AM + UFs group vs Simple AM group; p_b represented AM + OE group vs Simple AM group; p_c represented AM + OE group vs AM + UFs group.

Table 5. The relationship between clinical baseline data and the therapeutic effect of UAE in AM patients.

Clinical indicators	Effective group (n = 193)	Ineffective group (n = 50)	Statistic	p
Age (years)	41.13 ± 4.85	37.92 ± 4.98	t = –4.16	<0.001
Gravidity	3.00 (2.00, 4.00)	2.50 (1.00, 4.00)	Z = –1.28	0.200
Parity	2.00 (1.00, 2.00)	1.00 (1.00, 2.00)	Z = –2.01	0.045
Uterine volume (cm^3)	259.00 (191.60, 381.30)	266.55 (191.25, 336.38)	Z = –0.25	0.803
Duration of dysmenorrhea (years)	3.00 (2.00, 6.00)	4.00 (2.00, 7.00)	Z = –0.88	0.379
Hemoglobin (g/L)	101.00 (82.00, 121.00)	113.50 (84.75, 125.50)	Z = –0.91	0.360
CA125 (U/mL)	72.10 (36.20, 121.92)	82.62 (47.45, 171.40)	Z = –1.99	0.046
Comorbid UFs [n, %]	63 (32.64%)	8 (16.00%)	χ^2 = 5.32	0.021
Comorbid OE [n, %]	16 (8.29%)	15 (30.00%)	χ^2 = 16.82	<0.001

Note: CA125, cancer antigen 125. Measurement data with normal distribution were expressed as mean ± SD. An independent sample t-test was used for comparisons between two groups. Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Mann-Whitney U test was used for comparisons between two groups. Categorical variables were expressed as numbers and percentages, and the chi-square test was used for comparisons between groups. The $p < 0.05$ indicated a statistically significant difference.

Notably, the AM + OE group exhibited significantly lower HRQOL scores than both the simple AM group ($p_b < 0.001$) and the AM + UFs group ($p_c < 0.001$), whereas no significant difference was found between the simple AM and AM + UFs groups ($p_a = 0.52$). HRQOL scores in the simple AM group ($p < 0.001$) and the AM + UFs group ($p < 0.001$) continued to improve from 3 months postoperatively to the final follow-up, while no significant change was observed in the AM + OE group during this interval ($p = 0.799$).

3.4 Effect of UAE on NRS Scores in Patients With AM

Changes in NRS scores among the three groups were evaluated at baseline, 3 months postoperatively, and at the final follow-up (Table 4). No significant differences in NRS scores were observed among the three groups at baseline (H = 4.13, $p = 0.127$; $p_a = 0.05$, $p_b = 0.79$, $p_c = 0.26$) or at 3 months postoperatively (H = 1.37, $p = 0.504$; $p_a = 0.95$, $p_b = 0.24$, $p_c = 0.34$). At the final follow-up, NRS scores were significantly higher in the AM + OE group than in both the simple AM group ($p_b = 0.02$) and the AM + UFs group ($p_c = 0.003$), while no significant difference was observed between the latter two groups ($p_a = 0.26$) (H = 7.68, $p = 0.021$). Within-group comparisons revealed that NRS scores decreased significantly in all groups at both postoperative time points compared with baseline (all $p < 0.001$). No significant differences were observed between 3 months postoperatively and the final follow-up (all $p > 0.05$).

3.5 Association Between the Therapeutic Efficacy of UAE on AM Patients and Preoperative Baseline Characteristics

Based on predefined clinical efficacy criteria, patients were stratified into an effective group (n = 193) and an ineffective group (n = 50). As shown in Table 5, significant differences were observed between the two groups in age, parity, CA125 levels, and the presence of concomitant UFs and OE (all $p < 0.05$). Compared with the ineffective group, patients in the effective group were older, had higher parity, lower CA125 levels, a higher incidence of UFs, and a lower incidence of OE. No significant differences were observed between the two groups in terms of gravidity, uterine volume, duration of dysmenorrhea, or hemoglobin levels (all $p > 0.05$).

To identify predictors of treatment response, univariate logistic regression analyses were conducted with clinical efficacy (effective = 1; ineffective = 0) as the dependent variable (Table 6). Age, CA125 levels, coexistence of OE, and preoperative SSS were significantly associated with treatment efficacy (all $p < 0.05$). Variables with $p < 0.05$ in univariate analyses were subsequently included in the multivariate logistic regression model. All variables retained in the final multivariate model showed VIF <5, indicating no significant multicollinearity. After adjustment for potential confounding factors, coexistence of OE remained an independent predictor of poor treatment response (odds ratio [OR] = 0.287, $p = 0.004$). In contrast, older age (OR = 1.139, $p = 0.001$) and higher preoperative SSS (OR = 1.020, $p = 0.046$) independently predicted favorable clinical efficacy. Elevated CA125 remained negatively associated with treatment response (OR = 0.990, $p = 0.001$) (Table 7).

3.6 Association of UAE Treatment Efficacy With HRQOL and NRS Scores in Patients With AM

Changes in HRQOL and NRS scores were compared between the effective and ineffective groups at baseline, 3 months postoperatively, and at the final follow-up (Table 8). Preoperatively, no significant differences were observed between the two groups in either HRQOL or NRS scores (both $p > 0.05$). At 3 months postoperatively and the final follow-up, HRQOL scores were significantly higher, and NRS scores were significantly lower in the effective group than in the ineffective group (all $p < 0.001$). Within-group comparisons showed that, in both groups, postoperative HRQOL scores increased significantly and NRS

Table 6. Univariate logistic regression analysis of factors associated with treatment efficacy.

Variables	β	SE	Z	p	OR (95% CI)
Group classification					
AM	—	—	—	—	1.00 (Reference)
AM + UFs	0.580	0.420	1.381	0.167	1.786 (0.786–4.060)
AM + OE	–1.320	0.430	–3.070	0.002	0.267 (0.118–0.620)
Age (years)	0.110	0.030	3.733	<0.001	1.116 (1.061–1.187)
Uterine volume (cm^3)	0.001	0.001	0.924	0.356	1.001 (0.999–1.002)
Gravidity	0.120	0.098	1.224	0.221	1.128 (0.930–1.368)
Parity	0.308	0.169	1.822	0.068	1.361 (0.968–1.909)
Duration of dysmenorrhea (years)	–0.029	0.041	–0.707	0.480	0.972 (0.902–1.048)
Hemoglobin (g/L)	–0.009	0.009	–1.000	0.317	0.991 (0.974–1.009)
CA125 (U/mL)	–0.005	0.002	–2.500	0.012	0.995 (0.991–0.999)
Pre-SSS	0.030	0.010	3.000	0.003	1.030 (1.010–1.050)
Pre-HRQOL	0.009	0.009	1.000	0.317	1.009 (0.991–1.027)
Pre-NRS	–0.096	0.054	–1.778	0.075	0.908 (0.817–1.010)
Follow-up duration	0.028	0.022	1.273	0.203	1.028 (0.981–1.079)

Note: OR, odds ratio; CI, confidence interval; SE, standard error.

Table 7. Multivariate logistic regression analysis of factors associated with treatment efficacy.

Variables	β	SE	Z	p	OR (95% CI)	VIF
Intercept	–5.120	1.550	–3.299	0.001	0.006 (0.0003–0.124)	
Group classification						
AM	—	—	—	—	1.00 (Reference)	
AM + UFs	0.180	0.460	0.391	0.696	1.197 (0.486–2.951)	1.422
AM + OE	–1.250	0.430	–2.907	0.004	0.287 (0.133–0.619)	1.381
Age (years)	0.130	0.040	3.250	0.001	1.139 (1.051–1.234)	1.213
CA125 (U/mL)	–0.010	0.003	–3.333	0.001	0.990 (0.984–0.996)	1.294
Pre-SSS	0.020	0.010	2.000	0.046	1.020 (1.000–1.041)	1.452

Note: OR, odds ratio; CI, confidence interval; VIF, variance inflation factor.

scores decreased significantly compared with preoperative values (all $p < 0.001$). In the ineffective group, HRQOL scores increased significantly from 3 months postoperatively (68.97 [53.45, 76.72]) to the end of follow-up (70.26 [50.22, 85.56]; $p < 0.001$), while the increase in NRS scores over the same period (from 2.00 [1.00, 4.00] to 3.00 [1.00, 4.00]) did not reach statistical significance ($p = 0.199$). In the effective group, no significant changes in HRQOL or NRS scores were observed between 3 months postoperatively and the final follow-up (both $p > 0.05$).

3.7 Evaluation of the Therapeutic Effect of UAE in Patients With AM

The therapeutic efficacy of UAE differed significantly among AM subtypes (Table 9). The clinical efficacy rate was comparable between the simple AM group and the AM + UFs group (80.85% vs 88.73%, $p_a = 0.15$). In contrast, the AM + OE group exhibited a markedly lower clinical efficacy rate (51.61%) compared with both the simple AM group ($p_b = 0.001$) and the AM + UFs group ($p_c < 0.001$). Given the relatively small sample size of the AM + OE subgroup (n = 31), a post-hoc power analysis was performed. Based on observed response rates of 51.61% in the AM + OE group, 80.85% in the simple AM group (n = 141), and 88.73% in the AM + UFs group (n = 71), the estimated statistical power was approximately 0.89 for the comparison between the AM + OE and simple AM groups and approximately 0.98 for the comparison between the AM + OE and AM + UFs groups (two-sided $\alpha = 0.05$), indicating adequate power to detect the observed differences.

Kaplan-Meier survival analysis (Fig. 2) demonstrated no significant difference in the Kaplan-Meier curve between the simple AM group and the AM + UFs group ($p > 0.05$). In contrast, the Kaplan-Meier curve for the AM + OE group was significantly lower than those of the other two groups throughout the follow-up period (all $p < 0.05$), indicating that concomitant OE was associated with an increased risk of treatment failure following UAE in patients with AM.

4. Discussion

This study demonstrates that UAE results in significant and sustained improvements in symptom severity, pain and HRQOL in patients with AM. Notably, therapeutic responses varied by comorbid conditions: outcomes after UAE were comparable between patients with isolated AM and those with concomitant UFs, whereas patients with con-

Table 8. The relationship between the therapeutic effect of UAE in AM patients and HRQOL and NRS scores.

Clinical indicators	Time	Effective group (n = 193)	Ineffective group (n = 50)	Statistic	p_a
HRQOL score	Pre-operation	43.97 (27.59, 60.34)	43.97 (31.46, 59.27)	Z = –0.29	0.77
	3 months postoperatively	83.62 (70.69, 94.83)	68.97 (53.45, 76.72)	Z = –4.30	<0.001
	At the end of follow-up	93.10 (83.62, 98.28)	70.26 (50.22, 85.56)	Z = –6.88	<0.001
	Within-group comparisons	$\chi^2 = 272.67$, $p < 0.001$	$\chi^2 = 21.70$, $p < 0.001$		
	3 months vs pre-operation	<0.001	<0.001		
	End vs pre-operation	<0.001	<0.001		
	End vs 3 months	0.750	<0.001		
NRS score	Pre-operation	6.00 (4.00, 9.00)	7.50 (4.00, 10.00)	Z = –1.91	0.056
	3 months postoperatively	0.00 (0.00, 2.00)	2.00 (1.00, 4.00)	Z = –4.99	<0.001
	At the end of follow-up	0.00 (0.00, 1.00)	3.00 (1.00, 4.00)	Z = –7.25	<0.001
	Within-group comparisons	$\chi^2 = 268.45$, $p < 0.001$	$\chi^2 = 44.98$, $p < 0.001$		
	3 months vs pre-operation	<0.001	<0.001		
	End vs pre-operation	<0.001	<0.001		
	End vs 3 months	0.233	0.199		

Note: HRQOL, health-related quality of life; NRS, numerical rating scale; Non-normally distributed continuous variables were expressed as median (Q1, Q3) [interquartile range (IQR)]. Mann-Whitney U test was used for comparison between the two groups. For within-group longitudinal comparisons across different time points (pre-operation, 3 months postoperatively, and at the end of follow-up), the Friedman test (χ^2) was used, followed by the post hoc Dunn's test. The p_a represented the comparisons with the effective group. The $p < 0.05$ indicated a statistically significant difference.

Table 9. Evaluation of the therapeutic effect of UAE treatment on AM patients.

Clinical indicators	Simple AM group (n = 141)	AM + UFs group (n = 71)	AM + OE group (n = 31)	χ^2	p	p_a	p_b	p_c
Clinical efficacy				$\chi^2 = 18.61$	0.001	0.15	0.001	<0.001
Effective [n, %]	114 (80.85)	63 (88.73)	16 (51.61)					
Ineffective [n, %]	27 (19.15)	8 (11.27)	15 (48.39)					
Post-hoc power							0.89 (AM + OE vs Simple AM)	0.98 (AM + OE vs AM + UFs)

Note: the measurement data were expressed by the number of cases and percentage, and the chi-square test was used for comparisons between groups. The p_a represented AM + UFs group vs Simple AM group; p_b represented AM + OE group vs Simple AM group; p_c represented AM + OE group vs AM + UFs group; $p < 0.05$ indicated a statistically significant difference. Post-hoc power was calculated using the observed response rates and sample sizes with a two-sided $\alpha = 0.05$. Efficacy: >50% symptom relief at 32 months after UAE.

comitant OE experienced substantially less symptom relief and a significantly higher risk of treatment failure.

Baseline characteristics revealed significant age differences among the three patient groups. Patients with AM complicated by UFs were significantly older, which is consistent with previous reports indicating that the prevalence of UFs elevates with age and reaches a peak incidence at approximately 40 years [25]. UAE has been well established as a mature and widely accepted treatment modality for uterine fibroids and has recently emerged as an effective and cost-efficient option for the management of AM [26]. Previous studies have demonstrated that UAE yields substantial clinical improvement in patients with isolated AM as well as those with coexisting uterine conditions [27]. Consistent with these findings, the present study observed that older patients and those with AM coexisting with UFs experienced more favorable therapeutic responses, in line with evidence supporting the robust efficacy of UAE in AM patients with concomitant fibroids [11].

The UFS-QOL English questionnaire, first released in 2002, remains the sole validated instrument designed to evaluate UFs-related symptoms and their impact on QOL [24]. This instrument incorporates the SSS, in which higher scores indicate greater symptom burden, and the HRQOL scale, in which higher scores indicate improved QOL [28]. Previous studies have reported that UAE can reduce SSS cores by approximately 21–39 points within 6 months in patients with UFs [29]. Moreover, significant improvements in HRQOL and SSS scores have been documented at three months post-UAE in patients with AM [30]. Aligned with earlier evidence [15,31], our findings demonstrate that UAE significantly reduces symptom severity and improves quality of life across all AM subtypes. Notably, during follow-up, patients with AM complicated by ovarian endometrioma (AM + OE) exhibited relatively poorer long-term outcomes in symptom severity and quality of life compared with patients with simple AM or AM combined with uterine fibroids (AM + UFs). Quality of life continued to improve

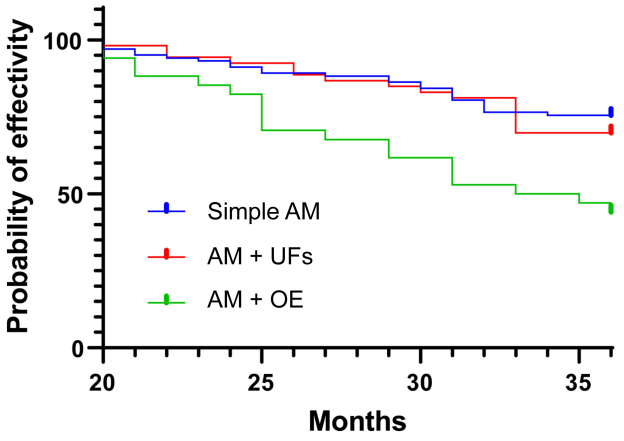

Fig. 2. Kaplan-Meier analysis of clinical efficacy following UAE in patients with AM over a 36-month follow-up period. Note: This is a partially zoomed-in figure showing sustained treatment efficacy from 20 to 36 months postoperatively (the full follow-up period covered 0-36 months). Kaplan-Meier curves were used to evaluate the probability of treatment effectiveness, and inter-group differences were assessed using the log-rank test.

beyond 3 months postoperatively in the simple AM and AM + UFs groups, whereas improvements in the AM + OE group were comparatively limited. Taken together, these findings indicate that UAE effectively alleviates symptoms and improves quality of life in patients with AM. However, patients with simple AM or AM + UFs generally achieve more sustained benefits, whereas those with AM + OE, although still deriving clinical benefit, demonstrate relatively weaker treatment responses and less favorable long-term outcomes.

The NRS is widely employed to quantify pain score intensity in clinical and research settings [32]. A previous study has shown that NRS scores in patients with AM drop substantially following treatment [33]. Gailė Maldutytė et al. [34] reported a significant positive interrelation between the number of sonographic features of AM and NRS scores, indicating a greater pain burden with increasing disease severity. Consistent with these observations, improvements in pelvic pain and QOL have been reported in women with AM who undergo UAE [35]. Approximately three months following UAE treatment, patients with AM typically exhibit notable symptom relief, marked improvement in overall health status, and a substantial decrease in pain scores [36].

This study also demonstrated a marked postoperative reduction in NRS scores across all groups, with the AM + UFs subgroup experiencing the most pronounced improvement in pain. In contrast, patients with AM + OE showed a more modest decline in pain scores. Univariate analyses revealed that age, CA125 levels, coexistence of OE, and preoperative SSS were significantly associated with treatment response. In the multivariate logistic regression model, concomitant OE remained an independent predictor of suboptimal response to UAE, indicating reduced treatment sensitivity in the AM + OE subtype. Conversely, older age and higher baseline SSS independently predicted favorable outcomes, while elevated CA125 levels were negatively associated with treatment efficacy. These findings are clinically plausible, as patients with a greater symptom burden often experience more substantial symptom relief following targeted vascular occlusion, whereas elevated inflammatory or disease-activity markers, such as CA125, may reflect a more complex pathological state that attenuates therapeutic benefit [16]. Kaplan-Meier analysis further corroborated that patients with AM + OE had a higher probability of treatment failure following UAE. Moreover, response-stratified analyses demonstrated that patients in the effective group achieved sustained and significant improvements in HRQOL and NRS scores postoperatively. Although improvements were less pronounced in the ineffective group, both pain and HRQOL remained significantly improved relative to baseline values, suggesting that UAE confers a degree of symptom relief even among suboptimal responders.

Notably, the attenuated therapeutic response observed in the AM + OE subgroup is unlikely to be solely attributable to the presence of OE. In this cohort, patients did not present with typical OE-associated symptoms, such as non-cyclic pelvic pain or dyspareunia, implying that the observed treatment pattern may instead reflect the intrinsic biological characteristics of this adenomyosis subtype. Previous studies have reported that certain AM lesions are characterized by more diffuse infiltration, heightened local inflammatory and pro-angiogenic activity, extensive collateral pelvic vascularization, and pronounced neural remodeling, all of which may limit post-embolization ischemic necrosis and increase susceptibility to reperfusion, thereby blunting pain control and lesion regression [37,38,39]. Additionally, increased myometrial fibrosis may confer greater tolerance to ischemia, further diminishing the therapeutic impact of embolization [40]. Collectively, these mechanisms support the notion that AM + OE represents a biologically more treatment-resistant phenotype. Future studies integrating preoperative imaging biomarkers, inflammatory indices, and measures of neural sensitization may improve patient stratification and help optimize therapeutic decision-making and outcome prediction.

Taken together, our findings demonstrate that UAE effectively alleviates symptoms and QOL in patients with AM, with superior efficacy observed in those with pure AM or AM complicated by UFs, and reduced effectiveness in cases with concomitant OE, which was also associated with an increased risk of treatment failure. However, several limitations of this study should be acknowledged. First, the retrospective design of this study may have introduced selection and information biases, and it lacks the methodological rigor of a randomized controlled trial. Second, the sample size, particularly that of patients with AM com-

plicated by OE, was relatively small, which may compromise the stability of subgroup analyses. Although post-hoc power analysis indicated adequate power for the observed between-group differences, the limited number of AM + OE cases may still introduce selection bias and limit the precision and generalizability of subgroup estimates. Therefore, these subgroup findings should be validated in larger, well-designed prospective studies. Additionally, variability in follow-up durations at study endpoints, including early withdrawal and completion at the 36-month follow-up, limits the interpretation of long-term outcomes, such that Kaplan-Meier analyses can only descriptively indicate poorer long-term efficacy in the AM + OE group. Future studies should aim to elucidate the biological mechanisms through which concomitant OE compromises the efficacy of UAE in AM, potentially involving alterations in the local microenvironment, vascular architecture, or variations in hormone sensitivity. Moreover, prospective randomized controlled trials comparing UAE with medical and surgical treatment interventions across different AM subtypes are warranted. Finally, a large-scale multicenter study is planned to further validate and refine the present findings.

5. Conclusion

UAE provides significant and sustained improvements in pain, symptom severity, and quality of life in patients with adenomyosis. Therapeutic efficacy was comparable between patients with simple AM and those with AM combined with uterine fibroids, whereas individuals with concomitant ovarian endometrioma experienced substantially poorer outcomes and a higher risk of treatment failure. Older age and lower CA125 levels were associated with a favorable treatment response, while ovarian endometrioma emerged as an independent adverse predictor of UAE efficacy. Collectively, these findings support UAE as an effective uterus-preserving therapeutic option for AM and underscore the value of preoperative patient stratification, particularly regarding ovarian endometrioma, to optimize therapeutic decision-making and clinical outcomes.

Key Points

• UAE significantly improved SSS, HRQOL, and NRS scores in patients with AM, with benefits evident at 3 months and sustained throughout follow-up.

• Clinical efficacy was comparable between the simple AM and AM + UFs groups, while patients with concomitant OE experienced significantly poorer symptom relief and lower response rates.

• Multivariate logistic regression identified OE as an independent predictor of poor response to UAE, whereas older age and higher baseline symptom severity predicted favorable outcomes and elevated CA125 levels were associated with reduced treatment efficacy.

• Responder demonstrated continued improvement in HRQOL and stable pain control over time, while non-responders showed deterioration after 3 months despite initial symptom improvement.

• Survival analysis further demonstrated that patients with AM + OE had a markedly higher risk of treatment failure following UAE than the other AM subtypes.

Availability of Data and Materials

The datasets analyzed during the current study are available from the corresponding authors upon reasonable request.

Author Contributions

ZT: Conceptualization, Methodology, Data curation, Formal analysis, Writing—original draft. HL: Methodology, Validation, Statistical analysis. CX: Clinical data collection, Patient follow-up, Resources. ZO: Technical support, Imaging interpretation, Supervision of interventional procedures. YW: Conceptualization, Writing – review & editing, Project administration, Supervision. WW: Conceptualization, Study design, Writing – review & editing, Funding acquisition, Supervision. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This retrospective study was approved by the Ethics Committee of The Affiliated Guangdong Second Provincial General Hospital of Jinan University (Approval No. 2024-KY-KZ-062-02). All procedures were conducted following the principles outlined in the Declaration of Helsinki and the measures for the Ethical Review of Biomedical Research Involving Humans issued by the National Health and Family Planning Commission of the People's Republic of China in 2016. As this study involved a secondary analysis of medical records obtained during routine clinical care, with a large sample size, complete removal of patient identifiers, no disclosure of personal privacy, no involvement of sensitive information, family genetic data, or genetic testing, and no inclusion of vulnerable populations, the requirement for individual informed consent was waived by The Affiliated Guangdong Second Provincial General Hospital of Jinan University.

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Conflicts of Interest

The authors declare no conflicts of interest.

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