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Mode of Delivery and Postpartum Ovarian Reserve: A Cross-Sectional Comparative Study of Antral Follicle Count in Primiparous Women

Aida Milani
Urmia University of Medical Sciences, Kowsar Hospital
Nasrin Hajiloo
Dr.n.hajiloo@gmail.com

Urmia University of Medical Sciences, Kowsar Hospital
Yalda Saniee
Imam Khomeini Hospital, Urmia University of Medical Sciences
Razieh Bakhshandeh
Independent Researcher
Mahasti Ghesmati
Urmia University of Medical Sciences, Kowsar Hospital
Kheyronnesa Zibarzani
Urmia University of Medical Sciences, Kowsar Hospital

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Abstract

Background

With the global rise in cesarean section rates, concerns have been raised regarding its potential long-term impact on ovarian reserve. This study aimed to compare the effect of vaginal delivery versus cesarean section on ovarian reserve, assessed by total Antral Follicle Count (AFC), in primiparous women within the first year postpartum, and to identify independent predictors of AFC.

Methods

This cross-sectional comparative study included 60 primiparous women (30 vaginal delivery, 30 cesarean section) aged 18–40 years, 6–12 months after a term singleton live birth. Total AFC (2–10 mm follicles) was measured by transvaginal ultrasonography performed by a single blinded operator. Demographic and clinical data were collected, and multiple linear regression was used to identify independent predictors of total AFC.

Results

The two groups were well-matched for maternal age (27.90 ± 5.11 vs. 27.97 ± 5.24 years, p = 0.960), BMI (24.15 ± 2.64 vs. 24.49 ± 2.75 kg/m², p = 0.627), and other baseline characteristics. Mean total AFC was 17.57 ± 4.97 in the vaginal delivery group and 16.50 ± 4.62 in the cesarean section group (p = 0.509). In multiple linear regression (R^2 = 0.164), only maternal BMI was a significant independent predictor of total AFC (B = − 0.688, p = 0.010), while mode of delivery (p = 0.523) and maternal age (p = 0.468) showed no significant association.

Conclusion

Uncomplicated cesarean section does not significantly affect postpartum ovarian reserve compared to vaginal delivery in primiparous women. Maternal BMI emerged as the only modifiable factor significantly associated with AFC, highlighting the greater importance of metabolic health over delivery mode in preserving ovarian reserve. These findings provide reassuring evidence for clinical counseling.

Background

Ovarian reserve, defined as the quantity and quality of the remaining oocytes within the ovaries, is a fundamental determinant of a woman's reproductive lifespan and future fertility potential(1, 2). In recent decades, significant socio-demographic changes, particularly the global trend toward delayed childbearing, have substantially increased the clinical relevance of ovarian reserve assessment(3). This shift has been paralleled by a marked rise in the utilization of assisted reproductive technologies (ART), making precise evaluation of ovarian reserve essential for individualized counseling, treatment planning, and realistic expectations regarding reproductive outcomes(4). As more women choose to postpone their first pregnancy, identifying modifiable and non-modifiable factors that influence ovarian reserve has become one of the most pressing challenges in modern reproductive medicine(2, 5).

Among various biomarkers, the total Antral Follicle Count (AFC) obtained by transvaginal ultrasonography has emerged as a practical, non-invasive, cost-effective, and reliable indicator of ovarian reserve(6, 7). AFC directly reflects the pool of gonadotropin-responsive follicles measuring 2–10 mm in diameter and provides immediate, real-time information about the available follicular cohort(8). Unlike serum Anti-Müllerian Hormone (AMH), which is a stable biochemical marker but requires laboratory analysis and incurs additional cost, AFC offers the advantage of being readily available during routine pelvic ultrasound and allows simultaneous evaluation of other pelvic structures(7,9). Due to its strong correlation with ovarian

response in assisted reproductive technologies and its utility in predicting poor or hyper-response, AFC has become one of the most widely used clinical tools for ovarian reserve assessment and individualized treatment planning(6, 10).

Concurrently, cesarean section rates have risen dramatically worldwide over the past two decades. Global estimates show that the cesarean delivery rate increased from approximately 7% in 1990 to more than 21% in 2018, with even higher figures reported in many middle-income countries(11, 12). In Iran, cesarean section rates range between 45% and 55%, substantially exceeding the World Health Organization's recommended ideal range of 10–15%(13, 14). This escalating trend has sparked growing concern among clinicians and researchers regarding the potential long-term effects of cesarean delivery on maternal pelvic anatomy, uterine scar integrity, and reproductive function(15). Although cesarean section is a life-saving procedure when medically indicated, the increasing frequency of non-medically justified cesareans has raised legitimate questions about its possible impact on future fertility, particularly through potential effects on ovarian reserve(16).

From a pathophysiological perspective, cesarean section is a major abdominal surgical procedure that involves incision of the lower uterine segment. This intervention may theoretically influence ovarian reserve through several mechanisms, including localized inflammatory responses and cytokine release, postoperative pelvic adhesion formation, and potential disruption or transient ischemia in the utero-ovarian collateral vascular network(17). Such changes could impair ovarian blood supply, promote oxidative stress, and accelerate follicular atresia within the ovarian cortex. Although these hypotheses are biologically plausible, the existing literature on the actual impact of delivery mode on ovarian reserve remains limited, inconsistent, and often inconclusive(18, 19). This gap between theoretical risk and empirical evidence underscores the urgent need for well-designed studies to determine whether cesarean section exerts a clinically meaningful long-term effect on the ovarian follicular pool.

Previous studies investigating the relationship between mode of delivery and ovarian reserve have yielded conflicting results(16, 18). While some earlier reports suggested a possible detrimental effect of cesarean section on ovarian reserve markers, more recent prospective investigations, notably Moini et al. (2019) and Mohr-Sasson et al. (2022), found no significant differences in AFC or serum Anti-Müllerian Hormone (AMH) levels between vaginal and cesarean deliveries in the postpartum period(18–20). However, many of these studies suffered from important methodological limitations, including heterogeneous study populations, inclusion of multiparous women, relatively short follow-up periods, inadequate adjustment for key confounding factors such as BMI and age, and lack of blinding in ultrasonographic assessments(15, 18, 19). As a result, a significant gap persists in the literature regarding the intermediate-term effects (6–12 months postpartum) of delivery mode on ovarian reserve in rigorously matched primiparous women. To address this gap, the present study was designed by restricting the sample to primiparous women, applying strict selection criteria, utilizing a single blinded operator for ultrasound assessments, and placing special emphasis on modifiable factors such as maternal body mass index (BMI). This study minimizes previous methodological limitations while providing the first valuable clinical data from Northwest Iran.

Methods

Study Design and Setting

This cross-sectional comparative study was conducted at the Department of Obstetrics and Gynecology, Kosar Educational-Therapeutic Hospital, Urmia University of Medical Sciences, Urmia, Iran, between 2023 and 2025. The study protocol was approved by the Ethics Committee of Urmia University of Medical Sciences (Ethics Code: IR.UMSU.REC.1402.352). Written informed consent was obtained from all participants prior to enrollment.

Participants

A total of 60 primiparous women aged 18–40 years who had delivered within the previous 12 months were enrolled. Participants were divided into two groups based on mode of delivery: normal vaginal delivery (NVD, n = 30) and cesarean section (CS, n = 30). All women had a history of a single, term (≥ 37 weeks), live singleton delivery.

Inclusion criteria were: primiparous women aged 18–40 years; history of first term singleton live birth within the past 12 months; and willingness to participate and provide informed consent.

Exclusion criteria included: history of infertility, miscarriage, or pelvic surgery; known endocrine, autoimmune, or chronic medical disorders (including diabetes, hypertension, or PCOS); history of chemotherapy, radiotherapy, or exposure to gonadotoxic agents; use of hormonal medications or contraceptives within the past 6 months; emergency cesarean section or non-Kerr incision; postpartum complications requiring blood transfusion, infection, or prolonged hospitalization; and inability to undergo transvaginal ultrasonography.

Data Collection and Outcome Measures

Demographic and clinical data including maternal age, body mass index (BMI), gestational age at delivery, neonatal birth weight, infant sex, and breastfeeding status were collected using a standardized questionnaire and medical records.

The primary outcome was ovarian reserve, assessed by the total Antral Follicle Count (AFC). Transvaginal ultrasonography was performed by a single experienced gynecologist who was blinded to the participants' mode of delivery. All scans were conducted using a high-resolution ultrasound system with a 7.5 MHz transvaginal probe. AFC was defined as the total number of antral follicles measuring 2–10 mm in diameter in both ovaries. In non-lactating women, ultrasonography was performed on days 2–5 of the menstrual cycle. In lactating women, it was performed at the time of study visit.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 21.0, IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Kolmogorov-Smirnov test. Normally distributed data are presented as mean ± standard deviation (SD), while non-normally distributed data were compared using the Mann-Whitney U test. Categorical variables are reported as frequencies and percentages and were compared using the Chi-square test or Fisher's exact test, as appropriate.

Multiple linear regression analysis was used to evaluate the independent association of delivery mode with total AFC while adjusting for potential confounders (maternal age and BMI). Delivery mode was coded as a binary variable (0 = vaginal delivery, 1 = cesarean section). Model fit was assessed using the coefficient of determination (R^2) and adjusted R^2. Multicollinearity among predictors was checked using the Variance Inflation Factor (VIF), and all values were well below the threshold of 10. A two-tailed *p*-value < 0.05 was considered statistically significant.

Results

A total of 60 primiparous women were included in this cross-sectional comparative study, with 30 women in the vaginal delivery group and 30 in the cesarean section group.

Baseline Demographic and Clinical Characteristics

The two groups were well-balanced with respect to key demographic and obstetric variables (Table 1). Mean maternal age was 27.90 ± 5.11 years in the vaginal delivery group and 27.97 ± 5.24 years in the cesarean section group (p = 0.960). BMI was also comparable between the groups (24.15 ± 2.64 vs. 24.49 ± 2.75 kg/m², p = 0.627). There were no statistically significant differences in gestational age at delivery, neonatal birth weight, breastfeeding status, or infant sex between the two groups (all p > 0.05). These findings confirm adequate matching of potential confounding factors between the study arms.

Table 1
Demographic and clinical characteristics of the study participants.

Variable	Vaginal Delivery (n = 30)	Cesarean Section (n = 30)	*p*-value
Maternal age (years)	27.90 ± 5.11	27.97 ± 5.24	0.960
BMI (kg/m²)	24.15 ± 2.64	24.49 ± 2.75	0.627
Gestational age (weeks)	39.03 ± 0.85	38.67 ± 0.66	0.121
Neonatal birth weight (g)	3330 ± 220.74	3216.67 ± 143.44	0.051
Breastfeeding (Yes), n (%)	20 (66.7%)	17 (56.7%)	0.595
Infant sex (Female), n (%)	16 (53.3%)	17 (56.7%)	1.000
Note: Data are presented as mean ± SD or number (percentage).			

Ovarian Reserve Assessment (Antral Follicle Count)

The primary outcome of the study was the total Antral Follicle Count (AFC). As shown in Table 2, the mean total AFC was numerically higher in the vaginal delivery group (17.57 ± 4.97) compared with the cesarean section group (16.50 ± 4.62); however, this difference did not reach statistical significance (p = 0.509). Similarly, no significant differences were observed in AFC of the right ovary (9.33 ± 2.60 vs. 8.83 ± 2.82, p = 0.519) or left ovary (8.23 ± 2.73 vs. 7.67 ± 2.97, p = 0.443) between the two groups.

Table 2
Antral Follicle Count according to delivery mode.

Parameter	Vaginal Delivery (n = 30)	Cesarean Section (n = 30)	*p*-value
Right ovary AFC	9.33 ± 2.60	8.83 ± 2.82	0.519
Left ovary AFC	8.23 ± 2.73	7.67 ± 2.97	0.443
Total AFC	**17.57 ± 4.97**	**16.50 ± 4.62**	**0.509**
Note: Data are presented as mean ± SD.			

Predictors of Total Antral Follicle Count

To assess the independent effect of delivery mode on ovarian reserve while controlling for potential confounders, multiple linear regression analysis was performed with total AFC as the dependent variable (Table 3). The overall model was statistically significant (model p = 0.018) and accounted for 16.4% of the variance in total AFC ($R^2 = 0.164$, adjusted $R^2 = 0.119$).

After adjustment, maternal BMI was the only significant independent predictor of total AFC (B = − 0.688, SE = 0.258, β = −0.266, t = − 2.664, p = 0.010), indicating a negative association between higher BMI and lower antral follicle count. In contrast, mode of delivery (B = − 0.826, p = 0.523) and maternal age (B = − 0.098, p = 0.468) were not significantly associated with total AFC.

Table 3
Multiple linear regression analysis for predictors of total Antral Follicle Count (AFC).

Predictor	Unstandardized Coefficient	Standard Error	Standardized β	t-value	*p*-value
Constant	36.924	6.113	—	6.04	< 0.001
Delivery mode (CS vs NVD)	−0.826	1.285	−0.064	−0.643	0.523
Maternal age (years)	−0.098	0.135	−0.073	−0.731	0.468
BMI (kg/m²)	−0.688	0.258	−0.266	−2.664	**0.010***

*Note: Dependent variable = Total AFC. Delivery mode coded as 0 = vaginal delivery, 1 = cesarean section. Model p = 0.018. *p < 0.05.*

Discussion

The present study demonstrated that uncomplicated cesarean section does not significantly affect postpartum ovarian reserve compared to vaginal delivery in primiparous women, as measured by total Antral Follicle Count (AFC) within the first year after childbirth. The mean total AFC was 17.57 ± 4.97 in the vaginal delivery group and 16.50 ± 4.62 in the cesarean section group, with no statistically significant difference between the two groups (p = 0.509). This lack of difference remained consistent even after adjustment for potential confounders in multiple linear regression analysis (p = 0.523 for delivery mode). These findings directly address the primary objective of the study and suggest that the surgical nature of an uncomplicated cesarean section does not appear to cause clinically meaningful damage to the ovarian follicular pool in the intermediate postpartum period.

These results are highly consistent with previous key prospective studies in the field. Moini et al. (2019), in a prospective cohort of Iranian women, reported no significant difference in either AFC or Anti-Müllerian Hormone (AMH) levels six months postpartum between cesarean and vaginal delivery groups(18). Similarly, Mohr-Sasson et al. (2022) demonstrated in a prospective study that cesarean delivery was not associated with a decline in AMH levels when measured before and three months after delivery(19). The present study extends and strengthens these findings in several important aspects. By limiting the sample to primiparous women, we eliminated the confounding effect of previous pregnancies and deliveries. Furthermore, we assessed ovarian reserve during the intermediate postpartum period (6–12 months), a less frequently studied time window. We also employed a single blinded operator for all transvaginal ultrasonographic examinations to reduce measurement bias and recruited participants from Northwest Iran. These methodological strengths enhance the robustness of our conclusion that uncomplicated cesarean section does not appear to cause clinically meaningful damage to the ovarian follicular pool.

A particularly noteworthy finding of the present study was that maternal BMI was the only significant independent predictor of total AFC (B = − 0.688, β = −0.266, p = 0.010). This robust association persisted after adjustment for delivery mode and maternal age, highlighting that metabolic status exerts a far greater influence on postpartum ovarian reserve than the surgical nature of delivery. Biologically, elevated BMI is closely linked to chronic low-grade systemic inflammation, insulin resistance, hyperinsulinemia, and increased oxidative stress within the ovarian microenvironment(21). These alterations can promote accelerated follicular atresia, impair granulosa cell function, and disrupt normal signaling in the hypothalamic-pituitary-ovarian (HPO) axis, ultimately reducing the pool of recruitable antral follicles(7). In contrast to mode of delivery, which is largely non-modifiable, BMI represents a critical and potentially reversible factor. This finding carries substantial clinical implications, suggesting that weight management before and after pregnancy may be a more effective strategy for preserving long-term ovarian reserve and reproductive potential than concerns regarding the choice of delivery mode(22).

The absence of a significant association between maternal age and total AFC in our study is likely explained by the relatively young and homogeneous age distribution of the participants (mean ≈ 28 years). This narrow age range effectively minimized the well-established physiological decline in ovarian reserve that becomes more pronounced after 35 years, thereby allowing a clearer assessment of the independent effect of delivery mode(23). Likewise, breastfeeding status showed no significant impact on AFC. Although lactation is associated with hyperprolactinemia and temporary suppression of the hypothalamic-pituitary-ovarian axis, this effect appears to be predominantly functional and reversible rather than causing structural depletion of the antral follicle pool in the intermediate postpartum period(24).

Strengths and Limitations

The present study has several methodological strengths. The two groups were well-matched for key confounders such as maternal age, BMI, gestational age, neonatal birth weight, and breastfeeding status. All transvaginal ultrasound examinations were performed by a single blinded experienced gynecologist, minimizing inter-observer variability. Strict inclusion/exclusion criteria were applied, and the study was limited to primiparous women evaluated in the intermediate postpartum period (6–12 months). Additionally, it provides data from Northwest Iran, a region underrepresented in the international literature on postpartum ovarian reserve.

Nevertheless, several limitations should be acknowledged. First, the relatively modest sample size (n = 60) may have limited the statistical power to detect small but clinically meaningful differences in AFC. Second, the cross-sectional design precludes firm causal inferences and longitudinal assessment of ovarian reserve changes. Third, ovarian reserve was evaluated solely by AFC; concurrent measurement of serum Anti-Müllerian Hormone (AMH) (a more stable, cycle-independent marker) was not performed. Fourth, as a single-center study in Northwest Iran, the findings may have limited generalizability to other ethnic, genetic, or socioeconomic populations. Finally, despite careful control of major confounders, unmeasured factors such as genetic predisposition, nutritional status, and long-term environmental exposures could have influenced the results.

Conclusion

In conclusion, this study demonstrates that uncomplicated cesarean section does not significantly affect postpartum ovarian reserve compared to vaginal delivery in primiparous women, as measured by total Antral Follicle Count within the first year after childbirth. Importantly, maternal BMI emerged as the only significant modifiable predictor of AFC, highlighting that metabolic health plays a more decisive role than delivery mode in preserving ovarian reserve. These findings provide reassuring, evidence-based information for clinical counseling, allowing physicians to alleviate maternal concerns regarding the long-term reproductive consequences of cesarean delivery. Future large-scale prospective cohort studies with longer follow-up, concurrent AMH measurement, and broader populations are needed to confirm these results and better define the role of modifiable metabolic factors in postpartum reproductive health.

Abbreviations

AFC
Antral Follicle Count
AMH
Anti-Müllerian Hormone
ART
Assisted Reproductive Technologies
BMI
Body Mass Index
CS
Cesarean Section
HPO
Hypothalamic-Pituitary-Ovarian
NVD
Normal Vaginal Delivery
PCOS
Polycystic Ovary Syndrome
SD
Standard Deviation
SPSS
Statistical Package for the Social Sciences

VIF
Variance Inflation Factor
WHO
World Health Organization

Declarations

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Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Urmia University of Medical Sciences (IR.UMSU.REC.1402.352). Written informed consent was obtained from all participants before enrollment.

Author Contributions

Conceptualization: Kh.Z, R.B

Methodology: N.H, R.B

Investigation and Data Collection: A.M, Y.S

Ultrasound Assessments: Y.S

Formal Analysis: M.Gh

Writing - Original Draft: A.M

Writing - Review & Editing: All authors

Supervision: N.H

Consent for publication

Not applicable.

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Competing interests

The authors declare that they have no competing interests.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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