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AMH/AFC Ratio as a Predictor of Clinical Pregnancy in ICSI: A Multicenter Study From Iraq

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Abstract

Objectives: Predicting outcomes in intracytoplasmic sperm injection (ICSI) cycles is challenging. Traditional markers provide limited insight into ovarian reserve and pregnancy potential. Recent studies suggest that combining anti-Müllerian hormone (AMH) with gonadotropin metrics may enhance prognosis. This study evaluates the diagnostic utility of LH/AMH, FSH/AMH, and AMH/AFC ratios for predicting pregnancy after day-5 embryo transfer in ICSI cycles.

Materials and Methods: This multicenter prospective observational study enrolled 120 infertile women aged 20–35 years (AFC ≥ 5, AMH ≥ 0.5 ng/mL, BMI < 30 kg/m²) undergoing a standardized GnRH-antagonist ICSI protocol. Day-2 serum LH, FSH, and AMH levels and transvaginal ultrasound–derived AFC were measured. Ratios (LH/AMH, FSH/AMH, AMH/AFC) were calculated. Outcomes included biochemical pregnancy and clinical pregnancy.

Results: Biochemical and clinical pregnancy rates were 29.2% and 18.3%, respectively. AMH and AFC exhibited positive correlations with mature follicles, oocyte yield, fertilization rate, FOI, OSI, and FORT, whereas LH, FSH, and their AMH-based ratios showed inverse correlations. The AMH/AFC ratio demonstrated a modest association with clinical pregnancy (OR 0.02; 95% CI 0.001–5.39; $P = 0.17$) and yielded an AUC of 0.59, specificity of 78.6%, and PPV of 85.6% at a cut-off ≤ 0.13, which were not significant.

Conclusions: The AMH/AFC ratio can be a supplementary predictor of ovarian reserve, with potential clinical value in counseling and designing cycles for ICSI.

Keywords: Anti-Müllerian hormone, Antral follicle count, LH/AMH ratio, FSH/AMH ratio, Clinical pregnancy

Introduction

Infertility, which is the inability to conceive within a year of frequent, unprotected sexual intercourse, is present in about 186 million people across the world and is consistently high across different levels of income. The rising number of infertile couples affects population growth and the happiness of the individuals. Infertility not only stands as a challenge to the couple but is a matter of public health, with consequences including social and economic issues, which may result in stigma, marital discord, and psychological distress (1). Assisted reproductive technology (ART) is the collective term for fertility therapies involving the use of eggs or embryos outside the body with the objective of improving the chances of a successful pregnancy and a healthy offspring. The present available technology for the treatment of infertility is in vitro fertilization, which may or may not involve intracytoplasmic sperm injection (ICSI) (2).

ICSI is an invasive procedure used to treat infertility. This method involves penetrating the egg's plasma membrane, followed by sperm injection. Depending on their quality and the patient's circumstances, as determined by the physician's judgment, certain embryos are transferred to the woman's uterus two to three days later (3,4). The traditional predictors of reproductive potential during infertility treatments include maternal age (5), early follicular phase blood levels of follicle-stimulating hormone (FSH) (6), and, less commonly, serum inhibin B (INH-B) (7,8). However, these parameters are not particularly reliable for assessing the number and quality of remaining oocytes in the ovary or the likelihood of pregnancy through treatment (9). Among these indicators, FSH indirectly assesses ovarian reserve by inhibiting hypothalamic FSH production through the action of ovarian estrogen (E2). The rise of FSH during the early part of the menstrual cycle indicates a decrease in ovarian hormone output, signaling dysfunction in the ovarian follicular cohort (10). Recently, there has been significant interest in using anti-Müllerian hormone (AMH) and antral follicle count (AFC) as indicators for predicting ovarian hyperstimulation outcomes with gonadotropins in IVF/ICSI. These markers are believed to be more effective in predicting a positive pregnancy test in the ICSI program because they reflect the number of small follicles ready for recruitment during stimulation, potentially better predicting how a patient will respond

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to treatment (11-13). Most studies have found that AMH is a better marker than the other parameters (14-16). Meanwhile, its predictive value is similar to that of AFC (12,17). FSH is a pituitary hormone that promotes granulosa cell growth, oocyte development, and estrogen production in women's ovaries (18,19). During male fetal sex differentiation, AMH is secreted by Sertoli cells within the testes, leading to the regression of Müllerian structures (20,21).

The rationale for assessing the predictive importance of the interaction between LH and AMH is based on previous findings and hypotheses. Initially, while LH alone seems not to predict IVF outcomes, the FSH/LH ratio did (22,23). In vitro studies have shown that AMH inhibits the recruitment of follicle development from the dormant primordial follicle pool and decreases FSH-induced growth of preantral follicles (24). Human granulosa cells cultured with high levels of AMH display reduced aromatase activity and decreased responsiveness to FSH (25-27). These past studies suggest a pathophysiologically important link between LH, FSH, and AMH, especially in women with ovulatory issues. We hypothesized that analyzing the combined diagnostic value of the LH/AMH ratio, the FSH/AMH ratio, and the AMH/AFC ratio could predict various outcomes of ICSI. The aim of this study is to evaluate the usefulness of different ovarian reserve markers and their ratios in forecasting biochemical and clinical pregnancy in infertile couples undergoing ICSI.

Methods

Study Design and Settings

A prospective observational multicenter study design was used on a sample of 120 infertile women who attended the infertility clinic of 1) Al-Nahrain University, Higher Institute for Infertility Diagnosis and Assisted Reproductive Technologies, 2) Kamal Al-Samarrai Hospital, and 3) Fertility Center of Al-Najaf, Al-Sadr Medical City, Babylon Health Directorate — the patients were followed up between January 2024 and January 2025. This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research (28).

Women were divided according to their outcomes into two groups: pregnancy (biochemical and clinical) and negative pregnancy. The effect of laboratory data (LH/AMH ratio, FSH/AMH ratio, and AMH/AFC ratio) on pregnancy outcomes was evaluated.

Inclusion and Exclusion Criteria

All infertile ladies on their first trial of ICSI, between 20 and 35 years, AFC ≥5 or AMH ≥0.5 ng/mL, fresh embryo transfer at day five, body mass index (BMI) <30 kg/m^2, and patients receiving GnRH antagonist protocol.

Polycystic ovary syndrome patients, individuals with a history of recurrent miscarriage, endocrine disorders, stage III or IV endometriosis, uterine anomalies, all cases of male infertility, to minimize confounding factors, abnormal karyotypes in male and/or female partners, hydrosalpinx, systemic diseases, positive tests for sexually transmitted infections, cycles involving vitrified/thawed oocytes or embryos, cycles using donated oocytes or embryos, frozen sperm cycles, surgical sperm retrieval procedures, cycles with preimplantation genetic testing, canceled cycles before fresh embryo transfer, ectopic pregnancy outcomes, testicular sperm in cases of obstructive and non-obstructive azoospermia, and cases with recurrent miscarriage.

Data Collection Process

On days 2 or 3 of the cycle, a detailed history is obtained from the woman, followed by a pelvic exam and transvaginal ultrasound (Medison, South Korea) to evaluate the AFC. Hormone levels are quantitatively measured, including serum LH, FSH, and AMH levels.

ICSI Protocol

The antagonist protocol and controlled ovarian stimulation (COS) began on day 2 of the cycle with recombinant FSH (Gonal-F®, Serono, Italy). The starting dose, ranging from 150 to 300 mIU/day, was adjusted based on body weight, age, and number of antral follicles. Transvaginal ultrasound examinations were performed every 2–3 days to monitor follicle development and endometrial growth. On the 7th stimulation day, a daily subcutaneous injection of 0.25 mg gonadotrophin antagonist (Cetrotide®, Merck-Serono, Germany) was given until at least three follicles measured over 18 mm. Then, 250 μg of recombinant human chorionic gonadotropin (hCG) (Ovitrelle, Merck-Serono, Germany) was administered. Ovum retrieval was scheduled for 35–36 hours after hCG injection, guided by transvaginal ultrasound.

Laboratory Hormonal Analysis on Cycle Day 2

A volume of ten milliliters of venous blood was collected from the antecubital fossa using a disposable syringe and subsequently transferred into a clean gel plastic tube (AFCO®, Jordan) for hormone analysis. This procedure was conducted on the second day of the menstrual cycle, prior to the initiation of the ICSI program. The blood samples were centrifuged at 1,000 rpm for 10 minutes, after which the serum was aliquoted into Eppendorf tubes and stored at -40 °C for subsequent hormone analysis. The analysis was performed utilizing MiniVidas equipment. Serum levels of AMH (REF: 417011), FSH (REF: 30407), and LH (REF: 30406) were quantified employing a specific kit (bioMérieux SA, France).

Evaluation of the Oocytes and the Embryos

The evaluation of the number, quality, and maturity of the oocytes was performed based on the criteria set by the grading system of the European Society of Human

Reproduction and Embryology (ESHRE) grading system (29). The maturity of the oocyte was determined based on the germinal vesicle (GV), metaphase I (M-I), and metaphase II (M-II) criteria, where M-II represents mature oocytes. ICSI was done four hours post-retrieval of the oocyte, typically at 38-40 hours post-HCG administration, in order to allow the mitotic spindle full maturity and hence improve the chances of successful fertilization. The evaluation of the completion of the fertilization process was performed 16-18 hours post-insemination by calculating the rate of fertilization, which was determined by the percentage of successfully fertilized oocytes out of the total number of injected oocytes. The evaluation of the quality of the embryos followed on day three of in vitro culture before the transfer of the embryos. One to three embryos were transferred based on patient circumstances. Approximately 48 hours post-fertilization, when the embryos were at the 6- to 8-cell stage, the embryos were transferred.

Luteal Phase Support and Pregnancy Follow-Up Protocol

To support implantation and early pregnancy, luteal phase supplementation was initiated on the day of oocyte retrieval. Patients received 400 mg of micronized progesterone in the form of vaginal suppositories (Cyclogest®, Actavis, United Kingdom), administered twice daily. This regimen was maintained for a minimum of two weeks and extended up to 12 weeks of gestation in cases of confirmed pregnancy.

Biochemical pregnancy was then monitored by serum β-hCG levels 14 days following embryo transfer. If the test returned positive, luteal support was further maintained to support early pregnancy. Clinical pregnancy was then diagnosed with transvaginal ultrasonography at 5-6 weeks of pregnancy, defined as the presence of one or more intrauterine gestational sacs with detectable fetal cardiac activity.

Outcome Measures

The outcome measures evaluated in this study encompassed several principal indicators of ovarian response and fertilization potential. The fertilization rate was determined by dividing the number of fertilized oocytes by the number of mature oocytes retrieved, subsequently multiplying the quotient by 100. The follicle-oocyte index (FOI) was ascertained by dividing the number of oocytes collected following ICSI by the pre-treatment AFC, with the result multiplied by 100. The ovarian sensitivity index (OSI) was computed as the number of oocytes obtained after ICSI divided by the total dose of FSH administered (expressed per 1000 IU). The follicular output rate (FORT) is calculated by dividing the number of pre-ovulatory follicles (at least 15 mm in size) produced after ICSI stimulation by the total number of follicles measuring at least 11 mm in mean diameter before treatment (AFC), then multiplying the result by 100.

Efforts to Minimize Bias

To minimize inter-operator variation in AFC, all ultrasonographic scans were done by senior reproductive specialists at each site who adhered to a common protocol with respect to probe frequency, follicular measurement criteria, and menstrual cycle phases. Although there were three centers involved, all operators underwent a harmonization procedure before the start of the study to minimize inter-operator variations. Secondly, all samples were analyzed in one laboratory at each site using the same pre-analytic steps such as centrifuge speed and time from sample acquisition to freezing. Moreover, consistent ICSI stimulation and monitoring procedures were used across the different centers to minimize variations.

Sample Size Calculations

The linear multiple regression method was used to calculate the sample size through power analysis using G*Power 3.1.9.4, with an effect size of 0.1, a two-tailed alpha level of 0.05, a power of 0.93, and five predictors of successful pregnancy. The total sample size was 120 women.

Statistical Analysis

The Anderson-Darling test was used to assess the normality of the continuous variables, and the bivariate Spearman correlation was used to assess the linear relationship between various variables. Binary logistic regression analysis is used to assess the effect of biochemical parameters on the presence of biochemical and clinical pregnancy, receiver operator characteristics (ROC) are used to assess the diagnostic utility of various markers to predict biochemical and clinical pregnancy, and all analysis carried out in GraphPad Prism 10.4, 0.05 was considered the level of significant.

All included variables were complete, and no missing data were encountered for hormonal measurements, ultrasound-derived AFC, stimulation parameters, or pregnancy outcomes; therefore, no imputation procedures were required.

Results

The study included 120 women who underwent the ICSI protocol. They had a mean age of 28.325 years, a BMI of 22.467 kg/m², a median LH level of 4.0 IU/mL, an FSH level of 5.0 IU/mL, an AMH level of 2.85 ng/mL, and an AFC of 13.0. Regarding ICSI treatment protocol outcomes, the median total dose was 2250 mg, the number of mature follicles was 9.5, the number of oocytes retrieved was 10, the median fertilization rate was 65%, the median FOI was 71.43%, the median OSI was 4.67, the median FORT was 76.92%, biochemical pregnancy was achieved in 29.2%, and clinical pregnancy was achieved in 18.3%, as seen in Table 1.

High levels of LH and FSH showed an inverse significant correlation with the number of mature follicles, oocytes

Table 1. Baseline Clinical Characteristics and ICSI Protocol Outcomes of the Study Population

Variables	Value
Age (y)	28.325±2.726
BMI (kg/m²)	22.467±1.823
LH (IU/mL)	4.0 (3.03-6.3)
AMH (ng/mL)	2.85 (0.9-3.9)
FSH (IU/mL)	5.0 (4.0-7.0)
AFC	13.0 (7.0-20.0)
LH/AMH ratio	1.3 (0.9-7.58)
FSH/AMH ratio	1.55 (1.10-8.70)
AMH/AFC ratio	0.184 (0.1305-0.2330)
Total dose used[a]	2250.0 (1357.5-3068.75)
No. of mature follicles[a]	9.5 (4.0-18.0)
No. of oocytes retrieved[a]	10.0 (3.0-16.0)
No. of GV oocytes[a]	1.0 (0-2.0)
No. of (M-I) oocytes[a]	3.0 (1.0-8.75)
No. of (M-II) oocytes[a]	4.0 (2.0-7.0)
No. of embryos Grade 1 transferred[a]	2.0 (1.0 – 3.0)
Fertilization rate (%)[a]	65.0 (50.0-86.5)
FOI (%)[a]	71.43 (50.0-85.71)
OSI (/IU)[a]	4.67 (1.028-9.83)
FORT (%)[a]	76.92 (57.14-90.0)
Biochemical pregnancy rate (%)[b]	35 (29.2%)
Clinical pregnancy rate (%)[b]	22 (18.3%)

BMI: body mass index, LH: luteinizing hormone, AMH: Anti-Müllerian hormone, FSH: follicle-stimulating hormone, AFC: antral follicle count; GV: germinal vesicle; FOI: follicle-oocyte index; OSI: ovarian sensitivity index; FORT: follicular output rate.

[a] Data presented as median (interquartile range); [b] Data presented as number (percentage).

retrieved, GV, M-I, M-II, grade 1 embryo, fertilization rate, FOI, OSI, and FORT. At the same time, high levels of AMH and AFC showed a direct, significant correlation with the number of mature follicles, oocytes retrieved, GV, M-I, M-II, grade 1 embryo, fertilization rate, FOI, OSI, and FORT. High LH/AMH ratio and FSH/AMH ratio showed an inverse significant correlation with the number of mature follicles, oocyte retrieved, GV, M-I, M-II, grade 1 embryo, fertilization rate, FOI, OSI, and FORT. At the same time, a high AMH/ AFC ratio showed a direct, significant correlation with the number of M-I, FOI, OSI, and FORT, as seen in Figure 1.

Most of the variables did not show a significant association with biochemical and clinical pregnancy outcomes, as shown in Table 2. Notably, the AMH/AFC ratio demonstrated a marginal association with clinical pregnancy, with a low AMH/AFC ratio indicating an increased likelihood of clinical pregnancy, as illustrated in Figure 2.

The ability of various biochemical parameters to predict both biochemical and clinical (Table 3) pregnancy was explored using ROC analysis; the net results showed that AMH/ACF ratio had the highest ability to predict clinical pregnancy with 78.57% specificity and 85.6% positive predictive value at optimal cut off ≤0.13, as seen in Table 3.

Receiver operating characteristic (ROC) curve analysis demonstrated modest discriminatory ability for all evaluated ratios in predicting clinical pregnancy. The AMH/AFC ratio showed the highest AUC (0.59; 95% CI: 0.497–0.679), followed by the FSH/AMH ratio (AUC = 0.54) and the LH/AMH ratio (AUC = 0.54). However, pairwise comparison of ROC curves using the DeLong test revealed no statistically significant differences between the AMH/AFC ratio and either the FSH/AMH ratio ($P=0.433$) or the LH/AMH ratio ($P=0.451$). Similarly, for biochemical pregnancy, ROC analysis showed low discriminatory performance across all ratios, and DeLong testing confirmed no significant differences between AUCs. At the predefined cut-off value (≤0.13), the AMH/AFC ratio demonstrated moderate specificity (78.6%) and positive predictive value (85.6%), but limited sensitivity (40.9%), indicating restricted overall predictive performance (Figure 3).

Discussion

In this study, we assessed the response of several ovarian reserve markers and utilized the ratio of these markers to enhance their diagnostic usefulness. The results of ICSI in this study showed that 29.2% of patients achieved biochemical pregnancy, and 18.3% achieved clinical pregnancy. These findings are similar to those in other local and international studies; a recent study in Iraq reported a 26.66% pregnancy rate among 90 women

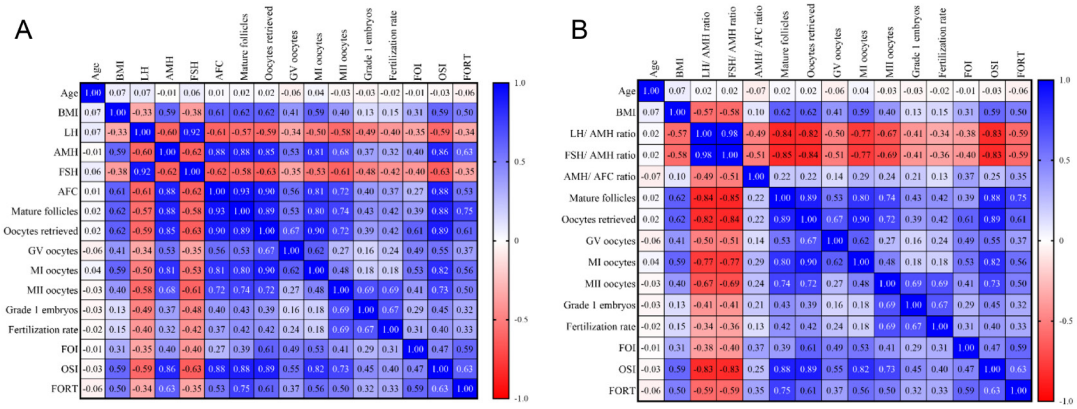

Figure 1. Correlation Matrix Heatmap Between LH, FSH, AMH, and AFC With Various ICSI Outcomes.

Table 2. Binary Logistic Regression Analysis Showing the Predictors of Biochemical and Clinical Pregnancy

Variables	Biochemical pregnancy		Clinical pregnancy	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Age	1.037 (0.896-1.201)	0.624	1.014 (0.855-1.204)	0.872
BMI	0.984 (0.792-1.223)	0.883	0.864 (0.660-1.130)	0.286
LH	1.019 (0.862-1.205)	0.825	0.982 (0.802-1.201)	0.857
AMH	0.932 (0.742-1.170)	0.543	0.959 (0.735-1.251)	0.757
FSH	1.017 (0.879-1.177)	0.822	1.015 (0.856-1.203)	0.867
AFC	0.987 (0.941-1.034)	0.576	1.007 (0.954-1.063)	0.805
LH/AMH ratio	1.000 (0.997-1.003)	0.990	0.998 (0.991-1.005)	0.553
FSH/AMH ratio	1.000 (0.998-1.003)	0.889	0.998 (0.992-1.004)	0.543
AMH/AFC ratio	0.223 (0.002-24.872)	0.533	0.020 (0.001-5.388)	0.170

OR: odd ratio, CI: confidence interval, BMI: body mass index, LH: luteinizing hormone, AMH: Anti-Müllerian hormone, FSH: follicle-stimulating hormone, AFC: antral follicle count.

undergoing ICSI. International studies showed pregnancy rates ranging from 22% to 34% (30-33). There is an increasing prevalence of infants conceived through ART. Women considering an ICSI cycle want to understand their chances of conception. Various indicators are used to predict the outcome before starting an ICSI cycle, with AMH and FSH being the most common.

According to Marschalek et al (34), the LH-AMH ratio can predict IVF, where the higher the ratio, the fewer oocytes are retrieved, and this is shown by poor response with high LH and low AMH. A low ovarian reserve is shown by high gonadotropins and AMH, while low LH, and the ratio was lower. The ratio, age, and the outcome were not predictors for fertilization and pregnancy. Only the outcome was determined by age. This aligns with broader evidence that ovarian reserve markers (indicating oocyte quantity) are weak predictors of reproductive potential when considered alone, in the absence of age (35). While the LH/AMH ratio might be a promising indicator of oocyte yield, its usefulness beyond this purpose (such as predicting embryo quality or pregnancy) remains unproven. More data are needed to confirm whether this ratio offers unique clinical insights beyond established markers, which was one of the reasons for conducting this study.

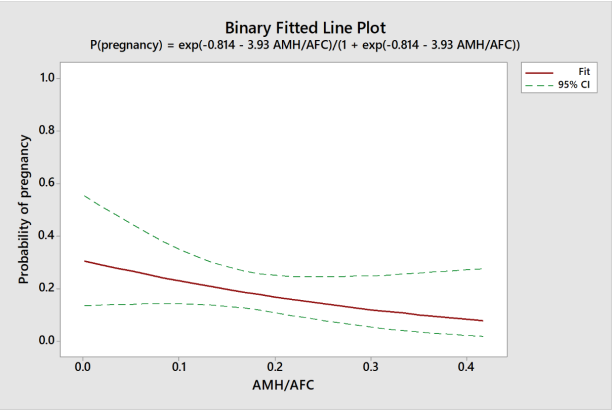

Figure 2. Probability Plot of the Association Between AMH/AFC Ratio and Increased Probability of Clinical Pregnancy.

The FSH/AMH ratio reflects ovarian reserve, with a high ratio indicating reduced reserve and a low ratio suggesting good reserve, often seen in younger women or those with PCOS. Gözükara et al (36) found this ratio useful in predicting poor IVF response, with a cutoff of about 11.36 distinguishing those likely to retrieve fewer than five oocytes with 80% sensitivity and 87% specificity (AUC 0.82). Higher ratios were associated with cycle cancellation or no oocyte retrieval, while lower ratios indicated a better response. However, the ratio did not correlate with clinical pregnancy rates. Overall, measuring FSH/AMH can help predict ovarian response and guide cycle management. Beyond IVF, the FSH/AMH ratio is proposed as a general marker of ovarian aging. A 2022 environmental health study utilized it to track ovarian decline with age under conditions of pollutant exposure (37). The ratio highlighted age-related changes better than AMH alone, with toxins accelerating its increase. It reflects subtle factors affecting ovarian reserve by combining FSH and AMH. Clinically, a high ratio indicates ovarian insufficiency, while a low ratio signals a large follicle pool, as in young PCOS patients, predicting a strong stimulation response. Although not standard, it shows promise for fertility assessments. More research could confirm its utility. AMH and AFC are interchangeable indicators of a woman's antral follicle pool. AMH is secreted by granulosa cells of small follicles, and AFC counts these follicles via ultrasound, so they correlate well. The AMH/AFC ratio shows the average AMH production per visible follicle. In healthy women, this ratio remains relatively constant. Research confirms a nearly linear relationship between AMH level and AFC across individuals (38).

The AMH/AFC ratio compares a biochemical marker of AMH with the actual count of antral follicles seen on ultrasound. It indicates the average AMH produced per follicle. Typically, AMH and AFC are closely related. Beyond PCOS diagnosis, the AMH/AFC ratio has gained

Table 3. Diagnostic Utility of Various Biochemical Markers to Predict Pregnancy

Variables	AUC	*P* value	Cut-off	SN	SP	NPV	PPV
Clinical Pregnancy							
Age	0.514	0.844	>28	22.73	91.84	38.5	84.1
BMI	0.567	0.287	≤23	86.36	28.57	21.3	90.3
LH	0.518	0.778	>3.2	81.82	31.63	21.2	88.6
AMH	0.521	0.771	≤0.64	27.27	85.71	30.0	84.0
FSH	0.526	0.701	>9.8	18.18	89.80	28.6	83.0
AFC	0.514	0.844	>28	22.73	91.84	38.5	84.1
LH/AMH ratio	0.541	0.553	>1	77.27	39.80	22.4	88.6
FSH/AMH ratio	0.542	0.551	>12.2	31.82	86.73	35.0	85.0
AMH/AFC ratio	0.590	0.182	≤0.13	40.91	78.57	30.0	85.6
Biochemical Pregnancy							
Age	0.540	0.499	≤15	74.29	36.47	32.5	77.5
BMI	0.507	0.897	≤24	94.29	18.82	32.4	88.9
LH	0.536	0.530	>3.4	77.14	36.47	33.3	79.5
AMH	0.545	0.451	≤0.64	25.71	87.06	45.0	74.0
FSH	0.511	0.852	>4.3	57.14	32.94	26.0	65.1
AFC	0.540	0.499	≤15	74.29	36.47	32.5	77.5
LH/AMH ratio	0.557	0.332	>1	74.29	41.18	34.2	79.5
FSH/AMH ratio	0.539	0.512	>10.9	28.57	85.88	45.5	74.5
AMH/AFC ratio	0.520	0.743	≤0.15	40.00	70.59	35.9	74.1

AUC: area under the curve, SN: sensitivity, SP: specificity, PPV: positive predictive value, NPV: negative predictive value.

attention for predicting ovarian responsiveness in assisted reproduction. Both AMH and AFC strongly predict oocyte yield in IVF, and combining them may improve individual predictions. A 2024 study analyzed over 2,100 IVF cycles and found the AMH/AFC ratio correlated more with ovarian response than either marker alone (39). The ratio had a correlation coefficient of about 0.62 with the Follicle Output Rate and the Follicle-to-Oocyte Index, surpassing AMH (~0.3) or AFC alone. Patients with high AMH relative to their antral count tend to have a higher proportion of oocytes. This might reflect different ovarian reserve patterns. For example, two patients with 10 antral follicles but different levels of AMH respond differently, with higher AMH per follicle often yielding more eggs. The ratio captures this difference. Indeed, it also agrees with clinical findings. Low AMH on a per-follicle basis (that is, low AMH with normal AFC) reflects small and less responsive follicles, whereas high AMH for each follicle reflects a dormancy but highly recruitable pool, as in some PCOS cases. These PCOS patients are usually anovulatory yet yield large numbers of oocytes upon stimulation, consistent with their elevated AMH/AFC ratio, which suggests many follicles are present. Overall, the AMH/AFC ratio is indicative of ovarian reserve and follicular efficiency. It could help identify PCOS subtypes and guide IVF stimulation protocols. However, interpretation depends on context, and results vary across studies. Standardizing measurement techniques is essential before widespread use.

While generally consistent, the relationship between AMH and AFC can vary under certain conditions. Studying the AMH/AFC ratio provides diagnostic insight.

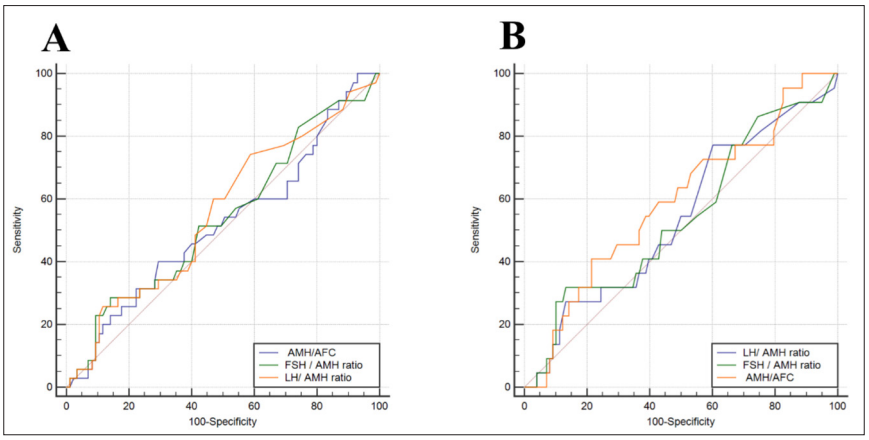

Figure 3. Receiver Operating Characteristic (ROC) Curves Comparing the Predictive Performance of the LH/AMH Ratio, FSH/AMH Ratio, and AMH/AFC Ratio for (A) Biochemical Pregnancy and (B) Clinical Pregnancy. The diagonal line represents the reference line of no discrimination.

About 15–20% of women show discordance between AMH and AFC, such as low AMH despite a decent follicle count, or vice versa (40). A 2019 study of over 1,100 IVF patients found that one in five had mismatched results. When discordant, AFC was usually a more reliable predictor of ovarian response. Women with normal AFC but low AMH still produced eggs, while those with low AFC and normal AMH had poorer outcomes (40). This suggests a low AMH/AFC ratio may indicate measurement anomaly or benign variation, while a high ratio could signal hidden issues. Clinically, if AMH and AFC give mixed signals, their ratio can clarify: a high AMH/AFC ratio might warrant caution, closer monitoring, or repeat tests.

Despite the advantages, the LH/AMH, FSH/AMH, and AMH/AFC ratios have important drawbacks, including the lack of standardization. To date, there is no standard for the ratios. Each study may have its units or kits for measuring the AMH, which may be in ng/mL or pmol/L, or for FSH/LH; each may employ different kits, such that the ratios' numerical values cannot be generally applied. For instance, the ratio of 11 for the prediction criteria can only be generally applied for certain units (FSH mIU/mL to AMH ng/mL). Different ratios may be required for other labs or subjects. Until such times that the ranges for each ratio are standardized, certain ratios' usage can be particular for the practitioner. Certain ratios may have overlapping ranges for each group, such that ratios within certain thresholds may indicate more than one group. For instance, ratios with high values may indicate menopause, but ratios with certain other values may indicate PCOS. A moderately high FSH/AMH ratio might be observed in a healthy woman late in her reproductive years or in a woman experiencing slightly premature ovarian aging; both may have similar ratios but different clinical implications. Technical Issues: Calculating the AMH/AFC ratio depends on an accurate AFC. Ultrasound-based AFC can be operator-dependent; errors such as missing follicles or counting a follicular cyst as a follicle can directly distort the ratio. Similarly, laboratory errors in measuring AMH can affect the ratio. Using two measurements introduces the potential for compounded errors—minor inaccuracies in FSH and AMH levels could significantly shift the ratio. Clinicians should ensure they use high-quality assays and ultrasounds when relying on these calculations.

Limitations

There are several limitations in this study. Firstly, the number of clinical pregnancy cases is numerically low, and therefore the study is not able to provide robust statistical predictions. Secondly, the study population was not varied, as the study comprised only young women with low body mass index and adequate ovarian reserve, and therefore it is not generalizable to the study population with advanced ages and low ovarian reserve or varying clinical profiles. Thirdly, though strict exclusion criteria were used, the study might have had uncontrolled factors, which may or may not have affected the outcomes.

Given the limited number of clinical pregnancy events, logistic regression and ROC analyses were treated as exploratory, and no multivariable adjustment or internal validation procedures were performed to avoid overfitting. Finally, the absence of external validation and the moderate AUC values emphasize the need for larger, prospective, and multiethnic studies before these ratios can be reliably used in clinical practice.

Conclusions

The AMH/AFC ratio appears to have an integrative role in defining the ovarian reserve with fair discriminatory ability in the prediction of clinical pregnancy in ICSI cycles. Its high positive predictive value encourages validation studies on larger groups of patients prospectively and in varying stimulation patterns.

Conflict of Interests

Authors declare that they have no conflict of interests.

Availability of Data and Materials

The dataset supporting the findings of this review is available from the corresponding author upon reasonable request.

Ethical Issues

This study was approved by the Research Ethics Committee of the College of Medicine, Mustansiriyah University (Approval No. 295, dated December 2023). The research adhered to the ethical principles outlined in the Declaration of Helsinki (1964) and its subsequent amendments. Written informed consent was obtained from all participants prior to inclusion.

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