Journal of
Gynecology and Women's Health
ISSN 2474-7602

Juniper Publishers
key to the Researchers

Research Article
Volume 27 Issue 2 - January 2025
DOI: 10.19080/JGWH.2025.27.556207

J Gynecol Women's Health

Assessment of Embryo Quality and Conception Rate in Patients Undergoing Invitro Fertilization/Intracytoplasmic Sperm Injection with Different Indications in Assisted Reproductive Technology

Roya Rozati[1]*, Wajeeda Tabasum[2], Mohammed Sarosh Ahmed[3], Vikram Aiman Ayapati[2], Ayapati Gautam Mehdi[2], Aleem Ahmed Khan[4], Abid Ali[5] and Muhammad Siddique Ahmed Khan[6]

[1]*Department of Obstetrics and Gynaecology, Shadan Institute of Medical Sciences, Medical and Research Director, Medical Health and Research Institute (MHRI), India*

[2]*Medical Health and Research Institute (MHRI), India*

[3]*Deccan College of Medical Sciences, India*

[4]*Centre for Liver Research and Diagnostics-DCMS, CMH Research and innovation, India*

[5]*Bhaskar Medical College, India*

[6]*Department of Biochemistry, Shadan Institute of Medical Sciences, India*

Submission: December 09, 2024; **Published:** January 03,2025

***Corresponding author:** Dr. Roya Rozati, MD (A.I.I.M.S, Delhi), F.R.C.O.G.(London), Department of Obstetrics and Gynaecology, Shadan Institute of Medical Sciences, Medical and Research Director, Medical Health and Research Institute (MHRI), Banjara Hills, Hyderabad, India, Email: drroyarozati@gmail.com

Abstract

Objective: The aim of this study is to assess embryo quality and Conception rate in patients undergoing Invitro Fertilization/intra-Cytoplasmic Sperm Injection (ICSI) outcomes (fertilization rate, embryo quality, pregnancy rate, and live birth rate) for couples with Endometriosis, PCOS, Male Infertility, Tubal Factor and unexplained infertility.

Methods: This is a retrospective study of 150 IVF/ ICSI Cases performed between 2018 and 2023 to compare outcomes in couples with PCOS, Endometriosis, Male Infertility, Tubal Factor, and unexplained infertility with about 4-5 cycles on average. Infertile couples were divided into 5 groups in each 30 cases were divided.

Results: Our findings suggest significant differences in reproductive outcomes based on the underlying infertility diagnosis. The percentage of success observed is Endometriosis (24.2%), PCOS (31.1%), Male Infertility (28.5%), Tubal Factor (32.6%) and unexplained infertility (33.1%).

Conclusion: In conclusion, this study demonstrates the significant influence of infertility diagnosis on reproductive outcomes in couples undergoing ICSI. PCOS was identified as the diagnosis with the highest clinical pregnancy and live birth rates, whereas Endometriosis was associated with markedly lower live birth outcomes. These findings emphasize the necessity for personalized treatment strategies in assisted reproductive technologies, considering the specific etiology of infertility to enhance success rates and optimize patient care. Tailoring interventions based on diagnosis may lead to improved reproductive outcomes and better-informed clinical decision-making.

Keywords: Invitro Fertilization; Intracytoplasmic sperm Injection; PCOS; Endometriosis; Male Infertility; Tubal Factor and unexplained infertility.

Introduction

Infertility is a major global health issue, impacting around 15% of couples worldwide, with 56% of these couples requiring medical intervention to achieve conception [1]. Reproductive disorders and infertility are associated with the risk and have a negative impact on pregnancy outcomes [2]. The morphological and developmental assessment of embryos and their subsequent correlation with successful implantation and live birth rates represents a fundamental determinant in optimizing clinical

outcomes within the field of Assisted Reproductive Technology (ART), with particular emphasis on cycles utilizing In Vitro Fertilization (IVF) or Intracytoplasmic Sperm Injection (ICSI) [3]. The evaluation of embryo viability through standardized grading systems, including parameters such as blastomere symmetry, fragmentation patterns, and developmental kinetics, serves as a critical prognostic indicator for reproductive success [4].

The efficacy of Assisted Reproductive Technology (ART) is influenced by the underlying etiology of infertility, with varied responses observed across different diagnostic categories [5]. Infertility and reproductive disorders, including endometriosis, adenomyosis, polycystic ovary syndrome (PCOS), and Unexplained infertility, can adversely impact pregnancy, affecting stages from implantation through to term [6]. Unexplained infertility accounts for approximately 20% of subfertility cases [7]. The heterogeneous nature of infertility, encompassing conditions such as endometriosis, Polycystic Ovary Syndrome (PCOS), tubal factor, and male factor infertility, presents unique challenges in optimizing treatment protocols and predicting success rates [8]. Furthermore, many individuals with reproductive disorders and/or infertility rely on assisted reproductive technologies (ART), which themselves may influence pregnancy outcomes independently [9].

Endometriosis, characterized by ectopic endometrial tissue growth, may adversely affect oocyte quality and embryo development through inflammatory mediators and oxidative stress [10]. Similarly, PCOS patients often exhibit altered folliculogenesis and oocyte maturation patterns, potentially impacting embryo quality [11]. Tubal factor infertility, while primarily mechanical in nature, may be associated with underlying inflammatory processes affecting the reproductive environment [12]. Male factor infertility, particularly in cases requiring ICSI, introduces additional variables in embryo development and quality assessment. The standardized evaluation of embryo quality parameters, including morphological characteristics, cleavage patterns, and blastocyst formation rates, provides crucial prognostic information [13].

Assessment of fertilization and embryo quality

Fertilization was evaluated to be approximately 16 hours post-insemination or post-intracytoplasmic sperm injection (ICSI). Normal fertilization was confirmed by the presence of two pronuclei (2PN) and the extrusion of the second polar body (PB) [14]. For conventional IVF, the fertilization rate was determined as the percentage of fertilized oocytes among those inseminated (or retrieved). For ICSI, two fertilization rates were assessed: the fertilization rate of injected oocytes and the fertilization rate of retrieved oocytes (oocytes allocated to ICSI) [15].

After assessing fertilization status, fertilized oocytes were cultured in 50-μL drops of medium under paraffin oil in a humidified atmosphere at 6% CO2 and 37°C until embryo transfer. Embryos fertilized via conventional IVF and those from ICSI were cultured separately. Embryo transfer was performed between days 2 and 5, with embryo quality evaluated immediately prior to transfer. Embryo quality was classified based on morphology on the day of transfer, with comparisons between IVF and ICSI-derived embryos limited to cycles where embryo transfer occurred on day 3 or day 5 post-retrieval.

Methods

This is a population-based retrospective study of 150 subjects aged 18-43 years from March 2018 to March 2023 representing the IVF or intracytoplasmic sperm injection (ICSI) treatment cycles from infertility from the Medical Health and Research Institute. This study proposal is reviewed by the Institutional Review Board. Cycles analyzed according to reported infertility diagnosis with endometriosis, PCOS, Tubal factor, Male Infertility, and Unexplained Infertility.

Patient data, including medical history, female age, body mass index (BMI) (automatically calculated after entering patient height and weight via the Hospital Information System (HIS), antral follicle count (AFC), and laboratory results, such as follicle-stimulating hormone (FSH) levels, along with details of the husband's semen analysis, including sperm count, motility, and morphology. Written informed consent to perform IVF/ ICSI

Stimulation Protocols for IVF/ICSI

Ovarian stimulation was conducted using either the Gonadotropin-releasing hormone (GnRH) long agonist protocol or the GnRH antagonist protocol.

GnRH Agonist Long Protocol

Pituitary downregulation in the mid-luteal phase of the menstrual cycle was achieved via intramuscular injection of 0.75-1.25 mg long-acting GnRHa or daily intramuscular administration of 0.05-0.1 mg short-acting GnRHa until the day of human chorionic gonadotropin (HCG) administration. Two to three weeks later, transvaginal ultrasound and blood tests for hormones (FSH, LH, and estradiol [E2]) were conducted to confirm full pituitary downregulation. Once downregulation was confirmed, controlled ovarian hyperstimulation (COH) was initiated with gonadotropin (Gn) at 75-300 U/day, with dosing based on individual BMI, baseline hormone levels, and antral follicle count (AFC). Follicular growth was monitored every three to five days through transvaginal ultrasound and blood hormone testing, with Gn dosage adjustments as needed. HCG (Livon, China) at 4000-10,000 U was administered to induce oocyte maturation when at least one follicle reached ≥18 mm or three follicles reached ≥17 mm in diameter. Transvaginal oocyte retrieval was performed 36 to 38 hours after the HCG trigger, guided by transvaginal ultrasound.

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GnRH Antagonist Protocol

Following the assessment of follicular condition through blood hormone tests (FSH, LH, and E2) and transvaginal ultrasound, gonadotropin (Gn) was administered at a dosage of 75 to 300 U/day to stimulate

follicular growth. Follicular development was monitored every three to five days using transvaginal ultrasound and blood hormone tests, with Gn dosage adjusted as needed. A GnRH antagonist was introduced either on the fifth to seventh day of Gn stimulation (fixed protocol) or based on the size of the dominant follicle and LH levels (flexible protocol). HCG (Livon, China) at 4000 to 10,000 U, or GnRHa at 0.2 mg, was administered to induce oocyte maturation once at least one follicle reached ≥18 mm or three follicles reached ≥17 mm in diameter. Oocyte retrieval was performed 36 to 38 hours after the trigger.

Embryo Scoring and Embryo Transfer

Embryos were scored according to morphology assessment. Cleavage stage embryos scored grade 1 and day 5 blastocysts scored grade 3 or grade 4 were considered good-quality embryos. Embryos were cultured in vitro until the third to fifth-day post-oocyte retrieval, after which up to three embryos were transferred to the uterus [16]. Luteal phase support began on the day of oocyte retrieval, using either daily intramuscular progesterone injections (60 mg/day) or transvaginal progesterone capsules (600 mg/day), and continued until the pregnancy test.

Statistical Analysis

An ANOVA was conducted, demonstrating a statistically significant difference between the groups.

Results

The descriptive information about the Socio-Demographic characteristics like age, BMI, durations of primary and secondary infertility of infertile couples undergoing ICSI are summarized in Table 1 For 30 patients in each group comprising of Endometriosis, PCOS, Tubal Factor, Male Infertility, Unexplained Infertility the results are comparable. The PCOS group had a significantly longer duration of infertility 7 years ±3.42 years followed by endometriosis (6.99±3.67), Tubal factor (6.72±4.42), Male infertility (5.62±2.72) and unexplained infertility (5.13±2.82). The Hormonal profiles were compared on day-2 did not show any significant difference for LH, FSH between PCOS, Endometriosis, Male Infertility, Tubal Factor and unexplained infertility.

Table1: Socio-Demographic baseline characteristics of infertile couples undergoing ICSI

Total Number of Cycles (n=150)	Endometriosis (n=30)	PCOS (n=30)	Tubal factor (n=30)	Male Infertility (n=30)	Unexplained Infertility	P-Value
Age	27.53±3.82	28.6±4.7	29.8.0 ±3.3	30.2±6.1	31±5.8	0.05*
BMI	23.11±3.51	28.2 ±3.1	27.8±4.9	27.1±5.8	26.9±6.2	0.001*
Infertility types Primary Secondary	16(53.3) 14(46.7)	13(43.3) 17(56.7)	12(40) 18(60)	18(60) 12(40)	22(73.3) 8(26.7)	
Duration of infertility (years)	6.99 ±3.67	7.42±3.2	6.72±4.42	5.62±2.72	5.13±2.82	0.05*
Basal serum FSH (mIU/mL)	6.12±3.72	4.14±1.58	6.38±2.01	6.7±2.3	6.47±1.8	<0.001*
Basal serum LH level (mIU/mL)	6.24±2.26	8.92±5.46	5.92±1.44	7.52±2.72	6.92±2.72	0.004*
Basal serum E2 level (pg/mL)	1,562.4±1057.3	3,219.2 ± 1,747.2	3,721.9± 1,847.2	3,576.1± 1,890.2	3,233.9± 1,488.0	<0.001*
Serum AMH (ng/ml)	1.52±1.91	7.34±3.73	1.81±1.32	2.42 ±1.61	2.6±1.91	<0.001*
Antral Follicle Count	7.32±3.21	14.5±3.2	11.2±3.5	12.6±3.8	11.2±6.8	<0.001*
Sperm concentration (× 106 /mL)	36.5±26.8	42.4±6.8	29.5±11.9	31±14.4	52.8±12.7	<0.001*
Sperm mobility (%)	4.0.2±3.3	46.8±7.2	41.8±5.2	42.4±1.2	53.4±11.6	<0.001*

Table 2 shows the Estradiol levels (2246.2±1441, 2520.1±1342, 1438.2±1592, 1814.6±1121.2, 1712.3±1023.2), Endometrial Thickness (7.45±2.4, 9.5±2.32, 7.1±2.8, 9.6±0.42, 8.42±3.3), Oocyte retrieved (12.91±11.34, 16.82±8.42, 12.32±5.41, 11.02±5.26, 12.05±4.26) in Endometriosis, PCOS,Tubal Factor, Male Infertility, and unexplained infertility respectively which is compared.

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Table 2: Ovarian Stimulation Outcomes after IVF/ICSI Based on Diagnosis

	Endometriosis (n=30)	PCOS (n=30)	Tubal factor (n=30)	Male Infertility (n=30)	Unexplained Infertility (n=30)	P-Value
Embryo Transfer Cycles						
E2 on the hCG injection day (Pg/ml)	2246.2±1441	2520.1±1342	1438.2±1592	1814.6±1121.2	1712.3±1023.2	<0.014*
Endometrial Thickness (mm)	7.45±2.4	9.5±2.32	7.1±2.8	9.6±0.42	8.42±3.3	<0.001*
Oocytes retrieved	12.91±11.34	16.82±8.42	12.32±5.41	11.02±5.26	12.05±4.26	0.032*
MII oocyte	9±7.6	12.1±6.62	8.42±4.21	8.44 ± 4.62	8.2±3.4	0.037*
MI oocyte	1.4±2.03	2.68±1.75	2.32±1.28	1.9±2.02	1.1±2.4	0.012*
GV oocyte	2.01±3	3.02±2.4	3.08±3.34	2.08±3	1.98±2.1	0.308

Table 3 shows the Implantation rate(37.2±20.3, 48.3±4.8, 38.7±20.3, 36.7±24.3, 45.2±4.92), Fertilization rate (66.7±20.8, 63.24±12.2, 72.7±20.3, 66.5±8.2, 63.5±20.8), cleavage rate (59.3±25.0, 58.5±17.9, 78.3±19.5, 80.1±22.5, 73.6±21.5), pregnancy rate (29.6%, 35.7%, 46.7%, 48.2%, 27%), clinical pregnancy (55.7%, 60.9%, 43.2%, 46.2%, 47%), Biochemical Pregnancy (4.2%, 7.5%, 8.2%, 11%, 6.6%), miscarriage rate (18%, 11.12%, 10.4%, 9.4%, 22.2%) and live birth rate (24.1%, 31.1%, 28.5%, 32.6%, 33.1%)in Endometriosis, PCOS, Tubal Factor, Male Infertility, and unexplained infertility respectively.

Table 3: Depicts the Conception rate of patients undergoing IVF/ICSI

	Endometriosis (n=30)	PCOS (n=30)	Tubal factor (n=30)	Male Infertility (n=30)	Unexplained Infertility (n=30)	P-Value
No. of obtained embryos	6.82	9.24	7.25	6.52	6.5	
Blastocyst Transfer	2 (1–4)	2 (1–3)	2 (1–4)	2 (1–3)	2 (1–3)	
Implantation rate	37.2±20.3	48.3±4.8	38.7±20.3	36.7±24.3	45.2±4.92	
Fertilization Rate	66.7±20.8	63.24±12.2	72.7±20.3	66.5±8.2	63.5±20.8	0.02*
Cleavage Rate	59.3±25.0	58.5±17.9	78.3±19.5	80.1±22.5	73.6±21.5	0.21
Pregnancy Rate	29.60%	35.70%	46.70%	48.20%	27%	<0.001*
Clinical Pregnancy	55.70%	60.90%	43.20%	46.20%	47%	
Biochemical Pregnancy	4.20%	7.50%	8.20%	11%	6.60%	
Miscarriage rate	18%	11.12%	10.40%	9.40%	22.20%	
Live Birth rate	24.10%	31.10%	28.50%	32.60%	33.10%	

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Our findings indicate that the primary indication for assisted reproductive technology (ART) with cumulative Clinical Pregnancy rate with the Live birth endometriosis (55.7%), polycystic ovary syndrome (60.9%), tubal factor (43.2%), male infertility(46.2%), and unexplained infertility(47.1%) with 4-5 consecutive cycles which is compared to with the conception rate and percentage of success including those with endometriosis (24.2%), polycystic ovary syndrome (31.1%), tubal factor (28.5%), male infertility(32.6%), and unexplained infertility(33.1%)with 4-5 consecutive cycles as depicted in Table 4 significantly influences embryo quality, with notable variations observed among different patient groups.

Table 4: Depicts Conception rate and Percentage of success in IVF/ICSI Cycles that resulted in cumulative live birth by Infertility with 4-5 consecutive cycles

Diagnosis	Percentage of success
Endometriosis	24.2
PCOS	31.1
Tubal Factor	28.5
Male Factor	32.6
Unexplained Infertility	33.1

Figure 1 presents the cumulative clinical pregnancy rate (CPR) and live birth rate (LBR) across different infertility types over 4–5 consecutive IVF/ICSI cycles. Endometriosis showed a CPR of 55.7% and LBR of 24.1%, reflecting lower live birth outcomes likely due to impaired endometrial receptivity and oocyte quality. PCOS demonstrated the highest cumulative rates, with a CPR of 60.9% and LBR of 31.1%, benefiting from higher ovarian response despite potential miscarriage risk. In male infertility cases, the CPR was 43.2% with a LBR of 28.5%, illustrating favorable outcomes with ICSI. Tubal factor infertility had a CPR of 46.2% and LBR of 32.6%, comparable to unexplained infertility, which reached a CPR of 47% and LBR of 33.1%. These results underscore variation in cumulative outcomes by diagnosis, with PCOS and unexplained infertility yielding higher cumulative live birth rates across consecutive cycles.

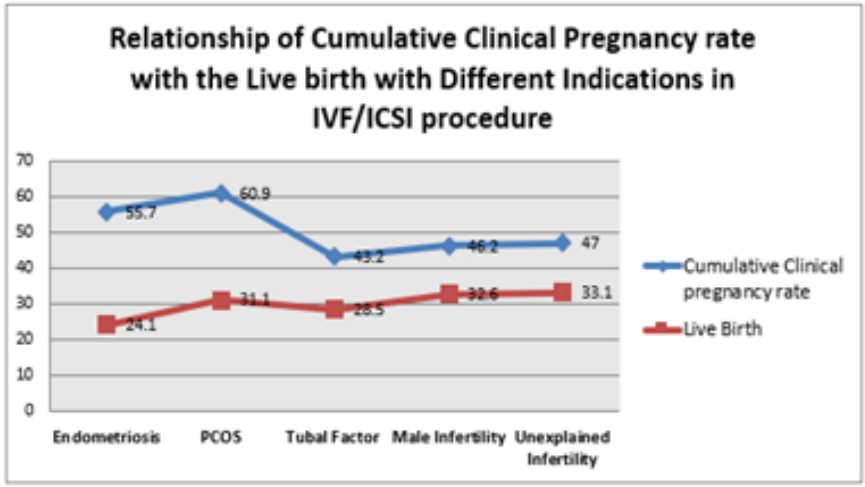

Figure 1: The relationship between the cumulative clinical pregnancy rate with the Live birth with different Indications with IVF/ICSI procedure with 4-5 Consecutive cycles

Figure 2 presents the conception rates and live birth success percentages per IVF/ICSI cycle across different infertility diagnoses. Live birth rates were observed as follows: endometriosis (24.2%), polycystic ovary syndrome (PCOS) (31.1%), tubal factor infertility (28.5%), male infertility (32.6%), and unexplained infertility (33.1%). These data reveal distinct variations in reproductive outcomes, with unexplained infertility and male infertility achieving the highest cumulative live birth rates per cycle, underscoring the influence of underlying infertility etiology on ART success.

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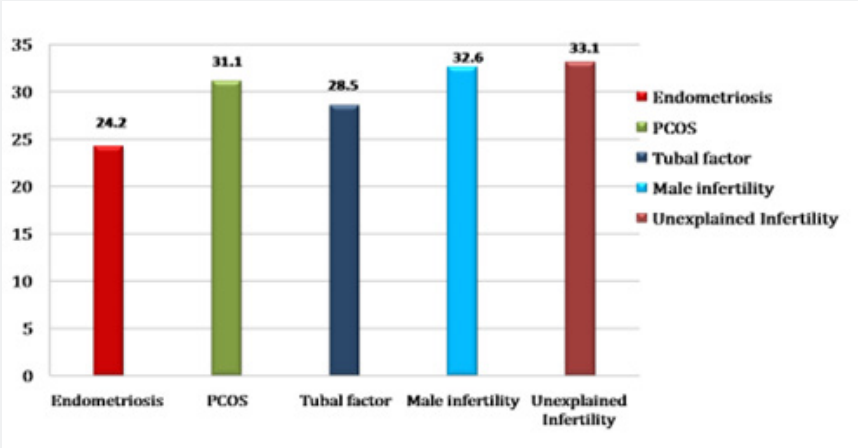

Figure 2: Illustrated Conception rate and Percentage of success in IVF/ICSI Cycles that resulted in live birth by Infertility.

Figure 3 presents a comparison of reproductive outcomes across different infertility types, detailing biochemical pregnancy, clinical pregnancy, and live birth rates. Biochemical pregnancy rates were 4.2% in endometriosis, 7.5% in PCOS, 8.2% in tubal factor infertility, 11% in male infertility, and 6.6% in unexplained infertility. Clinical pregnancy rates were highest in PCOS (60.9%) and endometriosis (55.7%), followed by unexplained infertility (47%), male infertility (46.2%), and tubal factor infertility (43.2%). Corresponding live birth rates were 33.1% for both PCOS and unexplained infertility, 32.6% for male infertility, 28.5% for tubal factor infertility, and 24.1% for endometriosis. These results underscore distinct patterns in pregnancy and live birth rates, reflecting variable reproductive outcomes across infertility diagnoses.

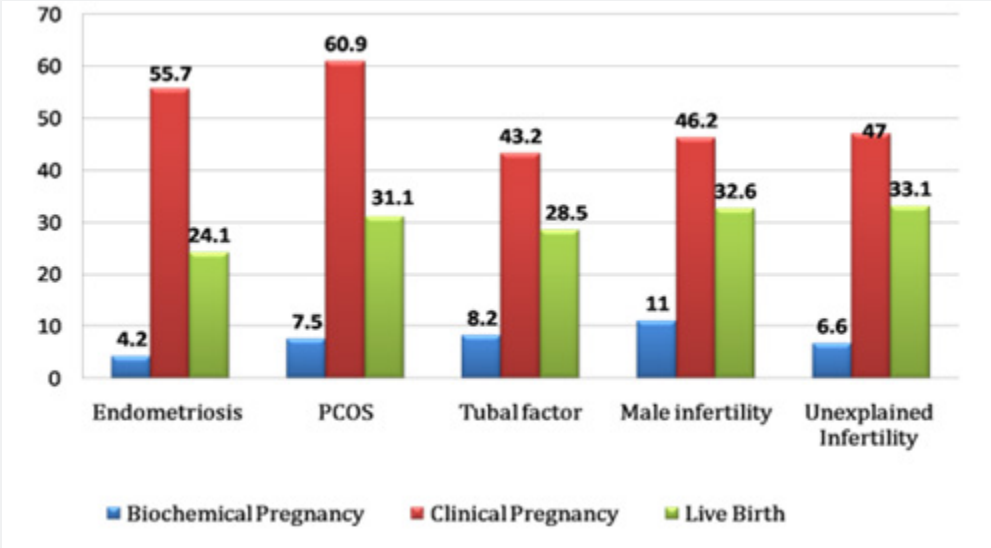

Figure 3: Illustrates percentage of Biochemical pregnancy, Clinical pregnancy and live birth in IVF/ICSI Cycles that resulted by Infertility.s

Discussion

The advancement of assisted reproductive technologies has enabled offspring production in infertile couples, with infertility to achieve conception through Intracytoplasmic Sperm Injection (ICSI). Infertility and reproductive disorders, such as endometriosis, adenomyosis, polycystic ovary syndrome (PCOS) and Male factor, tubal factor, may have a negative impact on pregnancy, from implantation until term. In addition, many patients with reproductive disorders and/or infertility require assisted reproductive technologies (ART), which independently

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may affect pregnancy outcomes. Patients with female infertility factors, including endometriosis and polycystic ovarian syndrome (PCOS), encounter specific challenges in assisted reproductive technology (ART). In these instances, oocyte quality may be adversely affected, which can hinder embryo development and lead to the production of lower-grade embryos. The assessment of embryo quality and conception rates among patients undergoing in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI) under various clinical indications like male factor infertility, female reproductive issues, unexplained infertility, and advanced maternal age, has influence the selection of ART techniques and may impact both embryo quality and subsequent conception rates. Our findings indicate that the primary indication for assisted reproductive technology (ART) significantly influences embryo quality, with notable variations observed among different patient groups with the conception rate and percentage of success, including those with endometriosis (24.2%), polycystic ovary syndrome (31.1%), tubal factor (28.5%), male infertility (32.6%), and unexplained infertility (33.1%) with 4-5 consecutive cycles.

Live birth rate is the ideal outcome variable for ART [17]. A research study conducted by Meena et al. 2019 [18] has shown higher PR and LBR in PCOS patients undergoing consistent physical activity compared to those undergoing dietary or pharmaceutical therapy alone. A study by Dang et al. 2021 [19] reported a 35% live birth rate following the first embryo transfer in cases of male infertility treated with IVF/ICSI, which aligns closely with our study's rate of 32.6%. Muteshi CM, et al. 2018 [20] reported a live birth rate of 24.1% with IVF/ICSI in patients with endometriosis, closely matching the 24.2% rate observed in our study. For patients with unexplained infertility, their study reported a live birth rate of 29.4%, while our study found a slightly higher rate of 33.1%.

Conclusion

The study highlights the significant influence of specific infertility etiologies on assisted reproductive technology (ART) outcomes, suggesting that treatment protocols in ART should be tailored to the underlying cause of infertility for optimized results. Patients with polycystic ovary syndrome (PCOS) and unexplained infertility achieved the highest success rates in terms of fertilization, embryo quality, and live birth outcomes. Conversely, those with endometriosis had comparatively lower live birth rates, suggesting a need for further individualized strategies to improve outcomes, particularly focusing on enhancing endometrial receptivity and embryo viability. This data underscores the potential for personalized treatment approaches to improve reproductive success rates and support more precise, diagnosis-informed clinical decision-making.

Acknowledgments

We acknowledge all the authors of the manuscript. All authors contributed equally to this work; RR designed the study; WT, VAA, GMA, and TNA, wrote the manuscript and did the statistical analysis. All authors reviewed and approved the final manuscript.

This research was funded by the Indian Council of Medical Research (ICMR), Government of India.

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How to cite this article: Roya R, Wajeeda T, Mohammed Sarosh A, Vikram Aiman A, Ayapati Gautam M, et al. Assessment of Embryo Quality and Conception Rate in Patients Undergoing Invitro Fertilization/Intracytoplasmic Sperm Injection with Different Indications in Assisted Reproductive Technology. J Gynecol Women's Health 2025: 27(2): 556207. DOI: 10.19080/JGWH.2025.27.556207

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