

"Study of IVF Technology and Embryo Transfer Techniques at Ajanta IVF Centre, Lucknow U.P. India

Km Rachana Pal¹, Dr. R.S.V. Gautam²

^{1,2}Department of Zoology Pt. Deen Dayal Upadhyay Govt. P.G College Saidabad Prayagraj (U.P.)

ABSTRACT

Infertility is a significant global reproductive health concern affecting millions of couples and has emerged as an important medical, social, and psychological issue. In vitro fertilization (IVF) technology has transformed infertility treatment by enabling fertilization outside the human body and facilitating embryo transfer under controlled laboratory conditions. The present study, titled "*Study of IVF Technology and Embryo Transfer Techniques at Ajanta IVF Centre, Lucknow,*" examines the biological basis, procedural techniques, and clinical outcomes associated with IVF and embryo transfer practices through a zoological and reproductive science perspective. The research integrates systematic review of scientific literature, reproductive biology concepts, and institutional data analysis from Ajanta IVF Centre. The study explores major components of assisted reproductive technology (ART), including ovarian stimulation protocols, oocyte retrieval, sperm preparation, fertilization methods, embryo culture systems, embryo grading, and transfer procedures. Special attention has been given to the role of embryo transfer as a critical determinant of IVF success and to factors influencing implantation and pregnancy outcomes. Analysis of institutional data indicates that reproductive outcomes are influenced by maternal age, infertility duration, embryo quality, endometrial receptivity, and laboratory practices. Advances such as blastocyst transfer, vitrification, individualized treatment protocols, and improved laboratory conditions have contributed to enhanced success rates and patient outcomes. The study highlights that IVF is not solely a technological intervention but a multidisciplinary application of reproductive physiology, embryology, and clinical practice. Findings demonstrate that optimization of embryo transfer techniques and personalized reproductive management can significantly improve treatment efficiency. The study contributes to the understanding of IVF from a zoological and clinical standpoint and provides insights for future improvements in assisted reproductive technologies and infertility management strategies.

Keywords: In Vitro Fertilization (IVF), Assisted Reproductive Technology (ART), Embryo Transfer, Reproductive Biology, Embryology, Infertility, Oocyte Retrieval, Blastocyst Transfer, Ajanta IVF Centre, Implantation Success.

INTRODUCTION

Infertility has emerged as a major global public health challenge affecting millions of couples worldwide. The World Health Organization (WHO) defines infertility as the inability to achieve pregnancy after twelve months or more of regular unprotected sexual intercourse. Approximately 15–20% of couples globally experience infertility, representing nearly 48 million couples and 186 million individuals. The burden of infertility varies across regions due to differences in healthcare access, disease prevalence, lifestyle factors, and socio-economic conditions. India faces a substantial infertility burden with an estimated 27.5 million infertile couples, making it one of the countries with the largest affected populations. Female infertility commonly arises from tubal disorders, polycystic ovary syndrome (PCOS), and ovarian dysfunction, while male infertility frequently involves reduced sperm count, motility, and morphology. Beyond medical concerns, infertility creates profound psychological, social, and economic consequences, especially in societies where childbearing remains closely linked with social identity and family expectations.

Ajanta Hospital and IVF Centre is located in Alambagh, Lucknow, Uttar Pradesh, India. The study site lies at latitude 26.8159642° N and longitude 80.904165° E. This centre is a reputed multi-speciality and fertility hospital equipped with advanced IVF and assisted reproductive technology facilities. The hospital serves as an important healthcare and

reproductive research centre in the Lucknow region and provides modern clinical and laboratory services for infertility management and related biomedical studies.

The development of Assisted Reproductive Technology (ART), particularly In Vitro Fertilization (IVF), represents one of the most significant achievements in reproductive medicine. IVF involves fertilization outside the body through retrieval of mature oocytes, laboratory fertilization using sperm, embryo culture, and subsequent transfer of embryos into the uterus. Since the birth of Louise Brown, the world's first IVF baby in 1978, IVF has transformed reproductive healthcare and enabled millions of infertile couples to achieve parenthood.

Historically, IVF evolved through decades of scientific investigation in reproductive biology. Early studies by Herman Fol on sea urchin fertilization and later experiments by Gregory Pincus and Min Chueh Chang in mammals laid the foundation for laboratory fertilization techniques. The pioneering collaboration of Robert Edwards and Patrick Steptoe ultimately resulted in successful human IVF. Subsequent technological developments—including controlled ovarian stimulation, cryopreservation, Intracytoplasmic Sperm Injection (ICSI), and Preimplantation Genetic Testing (PGT)—expanded IVF applications and improved treatment outcomes. In India, IVF development accelerated during the 1990s and 2000s, supported by the growth of specialized fertility centers and recent regulatory frameworks such as the Assisted Reproductive Technology (Regulation) Act, 2021.

From a zoological perspective, IVF represents a practical application of reproductive biology. Fundamental concepts including gametogenesis, fertilization mechanisms, reproductive endocrinology, embryogenesis, and hormonal regulation form the scientific basis of IVF procedures. Research using animal models such as sea urchins, frogs, mice, cattle, and primates contributed significantly to understanding sperm capacitation, oocyte maturation, embryo development, and endocrine regulation. Thus, IVF exemplifies the direct translation of zoological knowledge into clinical practice.

Research Objectives

1. *To study the biological basis of human reproduction and infertility in relation to Assisted Reproductive Technology (ART).*
2. *To examine the principles and procedures of In Vitro Fertilization (IVF) technology practiced at Ajanta IVF Centre, Lucknow.*
3. *To analyze the different stages of IVF treatment, including ovarian stimulation, oocyte retrieval, fertilization, embryo culture, and embryo transfer.*
4. *To study the embryo transfer techniques used at Ajanta IVF Centre and evaluate their role in improving implantation and pregnancy outcomes.*
5. *To assess the use of advanced reproductive technologies such as ICSI, blastocyst culture, cryopreservation, and frozen embryo transfer in IVF practice.*
6. *To evaluate the clinical outcomes and success rates of IVF procedures at Ajanta IVF Centre with reference to patient characteristics and infertility factors.*
7. *To identify factors influencing IVF success, including maternal age, infertility duration, embryo quality, and transfer protocols.*
8. *To examine the significance of embryo quality and laboratory conditions in successful assisted reproduction.*
9. *To understand the role of modern embryological techniques in enhancing IVF outcomes.*
10. *To suggest recommendations for improving embryo transfer practices and IVF success rates based on study findings.*

REVIEW LITERATURE

The female reproductive system plays a central role in assisted reproductive technology (ART), particularly through ovarian function and oogenesis. Oogenesis begins during fetal life when primordial germ cells migrate to the gonadal ridge, proliferate into oogonia, and enter meiosis before arresting as primary oocytes within primordial follicles. These follicles constitute a finite ovarian reserve that progressively declines with age. Following menarche, follicular recruitment is regulated by follicle-stimulating hormone (FSH), while luteinising hormone (LH) induces ovulation through meiotic resumption and maturation of the oocyte to metaphase II (MII), the stage suitable for fertilisation. The zona pellucida surrounding the oocyte plays an important role in sperm binding, fertilisation, and prevention of polyspermy, making it highly relevant in both conventional IVF and intracytoplasmic sperm injection (ICSI).

Male gamete biology is equally critical in reproductive success. Spermatogenesis occurs within seminiferous tubules under endocrine control and produces mature spermatozoa capable of fertilisation. Functional competence develops during epididymal transit and further through capacitation, a biochemical process preparing sperm for zona penetration. Male

factor infertility contributes to nearly half of infertility cases and includes oligozoospermia, asthenozoospermia, teratozoospermia, and azoospermia. The introduction of ICSI has transformed treatment outcomes, particularly for severe male-factor infertility.

Controlled ovarian hyperstimulation (COH) is fundamental to IVF, enabling the development of multiple follicles through exogenous gonadotropin administration. The principal stimulation approaches include long GnRH agonist and GnRH antagonist protocols. Recent trends emphasise protocol individualisation using ovarian reserve markers such as anti-Müllerian hormone (AMH) and antral follicle count (AFC). Antagonist protocols have gained prominence because of shorter treatment duration and significantly reduced ovarian hyperstimulation syndrome (OHSS) risk.

ICSI, initially developed for severe male infertility, involves direct injection of a spermatozoon into the oocyte cytoplasm and bypasses natural fertilisation barriers. However, evidence suggests no significant advantage over conventional IVF in non-male factor infertility, supporting selective rather than universal use. Following fertilisation, embryo culture under controlled laboratory conditions enables cleavage-stage or blastocyst-stage transfer. Blastocyst transfer generally demonstrates improved implantation and pregnancy outcomes due to enhanced embryo selection and better synchrony with endometrial receptivity.

Cryopreservation through vitrification represents a major advancement in ART, providing high embryo survival rates and facilitating frozen embryo transfer (FET). Evidence increasingly suggests that FET may produce outcomes comparable or superior to fresh transfers. Across IVF literature, female age remains the strongest predictor of treatment success, alongside ovarian reserve, embryo quality, endometrial receptivity, and lifestyle factors such as obesity and smoking. These biological and clinical determinants collectively influence reproductive outcomes and form the scientific basis of contemporary IVF practice.

RESEARCH METHODOLOGY

This study employed a multi-method evidence-synthesis research design integrating systematic literature review, documentary institutional case study, and analysis of aggregate clinical outcome data. The objective was to examine the biological principles, laboratory techniques, and clinical outcomes of In Vitro Fertilization (IVF), with special emphasis on practices and performance at Ajanta IVF Centre, Lucknow. The research was non-interventional in nature and did not involve primary human subject experimentation, direct patient recruitment, or access to identifiable medical records. All clinical information analysed consisted of aggregate, anonymised institutional data obtained from published reports and information shared for academic purposes.

A PRISMA-informed systematic review framework guided the literature component of the study. Scientific databases including PubMed, Google Scholar, Cochrane Library, and ICMR e-journal repositories were searched using combinations of keywords such as “*IVF outcomes India*,” “*controlled ovarian stimulation*,” “*embryo transfer techniques*,” “*ICSI vs IVF*,” “*blastocyst transfer*,” “*frozen embryo transfer*,” and “*ART regulation India*.” Priority was given to randomized controlled trials, systematic reviews, meta-analyses, and large cohort studies published between 2000 and 2025. Landmark studies and foundational publications predating this period were also incorporated where necessary.

Ajanta IVF Centre, Lucknow, served as the institutional case study site. The centre is a Category A accredited and ART-regulated facility offering services including IVF, ICSI, frozen embryo transfer (FET), preimplantation genetic testing (PGT), fertility preservation, and donor programmes. The centre follows individualized ovarian stimulation strategies using GnRH antagonist and long agonist protocols tailored according to age, ovarian reserve, and infertility diagnosis. Embryology procedures include time-lapse embryo monitoring, ICSI-based fertilisation, blastocyst culture, vitrification, and ultrasound-guided embryo transfer techniques.

Clinical outcome data were collected from multiple sources: Ajanta IVF institutional reports (2023–2025), ICMR/NRAR annual reports, ESHRE registry datasets, SART national statistics, and peer-reviewed Indian studies. The primary institutional dataset comprised 428 fresh embryo transfer cycles and included variables such as clinical pregnancy rate (CPR), live birth rate (LBR), fertilisation rate, ovarian hyperstimulation syndrome (OHSS), and treatment outcomes by age and protocol type.

Data analysis involved descriptive and comparative statistical approaches. Means, proportions, and 95% confidence intervals were calculated for outcome variables. Comparative analyses used Chi-square tests for categorical variables and Student’s *t*-tests for continuous data. Statistical processing and interpretation were performed using SPSS version 26 to ensure methodological consistency and reliability.

RESULTS AND DISCUSSION

Analysis of 428 fresh embryo transfer cycles conducted at Ajanta IVF Centre (2023–2025) demonstrated favorable clinical outcomes and highlighted important determinants of assisted reproductive success. The patient population had a mean female age of 30.8 years, with primary infertility accounting for 68.2% of cases. Polycystic ovary syndrome (PCOS) emerged as the most common infertility diagnosis (28.4%), followed by tubal factor infertility, male factor infertility, unexplained infertility, and diminished ovarian reserve. Among male-factor cases, oligozoospermia and oligo-asthenoteratozoospermia (OAT syndrome) predominated, reflecting the increasing contribution of male reproductive dysfunction to infertility patterns in India.

Regarding stimulation protocols, GnRH antagonist cycles represented the majority of treatments and demonstrated significant clinical advantages over long agonist protocols. Antagonist cycles required lower gonadotropin doses, shorter stimulation duration, and substantially reduced ovarian hyperstimulation syndrome (OHSS) rates. Severe OHSS was rare and absent among antagonist-triggered high-responder patients, emphasizing the safety benefits of individualized stimulation approaches.

Embryological outcomes were encouraging, with a mean oocyte retrieval of 11.8 per cycle and a mature oocyte rate of 78.4%. Fertilization outcomes significantly favored ICSI compared with conventional IVF (74.8% vs 62.4%; $p < 0.001$). However, despite improved fertilization efficiency, clinical pregnancy rates (CPR) did not differ significantly between ICSI and conventional IVF, indicating that ICSI should remain indication-based rather than universally applied.

Embryo stage at transfer significantly influenced outcomes. Day-5 blastocyst transfer achieved a CPR of 52.8%, markedly higher than Day-3 cleavage-stage transfer (34.6%). Frozen embryo transfer (FET) cycles also showed superior outcomes compared with fresh transfer cycles, supporting the growing evidence that optimized endometrial receptivity in FET cycles enhances implantation potential.

Female age remained the strongest predictor of IVF success. Clinical pregnancy rates progressively declined from 56.4% in women under 30 years to only 18.2% among women older than 40 years. This age-related reduction corresponded with declining ovarian reserve, reduced blastocyst formation, and increasing rates of oocyte aneuploidy.

Benchmark comparisons further demonstrated that Ajanta IVF Centre achieved a CPR of 43.2%, exceeding the Indian national average and aligning with outcomes reported by leading international reproductive centers. Collectively, these findings indicate that individualized stimulation protocols, blastocyst culture, selective use of ICSI, and patient age optimization contribute substantially to improved IVF outcomes and support Ajanta IVF Centre's performance as comparable with high-quality ART programs internationally.

CONCLUSION AND RECOMMENDATIONS

This dissertation presents a comprehensive zoological and clinical evaluation of In Vitro Fertilization (IVF) technology and embryo transfer practices at Ajanta IVF Centre, Lucknow, integrating reproductive biology with contemporary assisted reproductive technology (ART). Through systematic literature review, institutional data assessment, and analysis within a reproductive zoology framework, the study examined the biological foundations of IVF, clinical methodologies, and determinants of treatment outcomes. The findings demonstrate that IVF technology is fundamentally rooted in zoological sciences, particularly gametogenesis, reproductive endocrinology, fertilization biology, and developmental embryology. Each stage of IVF—from ovarian stimulation and laboratory embryo culture to embryo selection and transfer—depends upon principles derived from decades of reproductive research.

The study revealed that Ajanta IVF Centre achieved a clinical pregnancy rate (CPR) of 43.2% per fresh embryo transfer, exceeding the national average reported in India and approaching outcomes observed in advanced international centres. Such performance reflects the implementation of evidence-based treatment protocols, sophisticated embryology laboratory systems, and specialized clinical expertise. Among stimulation protocols, the GnRH antagonist regimen emerged as a safer and equally effective option compared with the long GnRH agonist approach, providing comparable pregnancy outcomes while significantly reducing ovarian hyperstimulation syndrome (OHSS). Similarly, Day-5 blastocyst transfer demonstrated superior pregnancy outcomes compared with cleavage-stage embryo transfer, supporting extended embryo culture for suitable patients.

Frozen embryo transfer cycles using vitrified blastocysts also showed favorable outcomes, reinforcing the growing role of freeze-all strategies, particularly in high responders and women with polycystic ovary syndrome (PCOS). Female age was

identified as the most significant predictor of IVF success, with a substantial decline in pregnancy rates among women above 40 years. Additionally, intracytoplasmic sperm injection (ICSI) improved fertilization rates but did not significantly enhance pregnancy outcomes in non-male factor infertility, supporting selective rather than universal use.

Based on these findings, several recommendations emerge. Continued use of GnRH antagonist protocols and expanded implementation of freeze-all strategies should be encouraged. Extended blastocyst culture and elective single embryo transfer should remain priorities to maximize pregnancy outcomes while reducing multiple pregnancy risks. Comprehensive age-related fertility counselling should be integrated into early consultations, particularly for women of advanced reproductive age. Development of a structured preimplantation genetic testing (PGT-A) program may further improve implantation efficiency in selected patient groups. Maintenance of a prospective quality registry is also recommended to facilitate continuous outcome monitoring and institutional benchmarking. Broader policy support, including public financing and expansion of ART services beyond major urban centres, may improve accessibility of infertility treatment across India.

The study is limited by reliance on aggregate institutional data, single-centre design, and restricted study duration. Nevertheless, it contributes significantly to zoological science by illustrating the direct relevance of reproductive biology to clinical ART practice. IVF represents an important interface between zoological science and medicine, highlighting the translational value of reproductive zoology in advancing fertility care and reproductive health outcomes.

REFERENCES

- [1] Agarwal, A., Mulgund, A., Hamada, A. & Chyatte, M.R. (2015). A unique view on male infertility around the globe. *Reproductive Biology and Endocrinology*, 13(37).
- [2] Al-Inany, H.G., Youssef, M.A., Ayeleke, R.O., Brown, J., Lam, W.S. & Broekmans, F.J. (2016). Gonadotrophin-releasing hormone antagonists for assisted reproductive technology. *Cochrane Database of Systematic Reviews*, 4, CD001750.
- [3] Assisted Reproductive Technology (Regulation) Act, 2021. Government of India. *Gazette of India, Extraordinary, Part II, Section 1*.
- [4] Atik, R.B., Christiansen, O.B., Elson, J., et al. (2017). ESHRE guideline: recurrent pregnancy loss. *Human Reproduction Open*, 2018(2), hoy004.
- [5] Bhattacharya, S., Hamilton, M.P.R., Shaaban, M., et al. (2001). Conventional in vitro fertilisation versus intracytoplasmic sperm injection for the treatment of non-male factor infertility. *BMJ*, 322(7302), 1554–1558.
- [6] Chang, M.C. (1959). Fertilisation of rabbit ova in vitro. *Nature*, 184, 466–467.
- [7] Edwards, R.G. & Steptoe, P.C. (1978). Birth after reimplantation of a human embryo. *Lancet*, 312(8085), 366.
- [8] Edwards, R.G. (1980). *Conception in the Human Female*. Academic Press, London.
- [9] ESHRE ART Working Group (2022). ART in Europe 2019: results generated from European registries by ESHRE. *Human Reproduction Open*, 2022(3), hoac022.
- [10] Gardner, D.K. & Schoolcraft, W.B. (1999). Culture and transfer of human blastocysts. *Current Opinion in Obstetrics and Gynecology*, 11(3), 307–311.
- [11] Gleicher, N. & Barad, D.H. (2018). Anti-Mullerian hormone (AMH) as a predictive marker. *Fertility and Sterility*, 110(4), 632–642.
- [12] HFEA (2022). *Fertility Treatment 2019–2020: Trends and Figures*. Human Fertilisation and Embryology Authority, London.
- [13] ICMR/NRAR (2023). *Annual Report on ART and Surrogacy in India 2022–23*. Indian Council of Medical Research, New Delhi.
- [14] IFFS Surveillance 2022. International Federation of Fertility Societies. *Global Reproductive Health*, 7(3).
- [15] Johansson, M., Liljevall, M., Jansson, A.K. & Bergh, C. (2013). Emotional and cognitive functioning during IVF and after delivery. *Human Reproduction*, 28(11), 3073–3082.
- [16] Kuwayama, M., Vajta, G., Kato, O. & Leibo, S.P. (2005). Highly efficient vitrification method for cryopreservation of human oocytes. *Reproductive Biomedicine Online*, 11(3), 300–308.
- [17] Levi Setti, P.E., Patrizio, P. & Albani, E. (2021). Frozen embryo transfer: clinical and basic aspects. *Reproductive Biomedicine Online*, 43(3), 403–408.
- [18] Maheshwari, A., Bhattacharya, S. & Johnson, N.P. (2018). Elective frozen replacement cycles for all: ready for prime time? *Human Reproduction*, 33(8), 1383–1395.