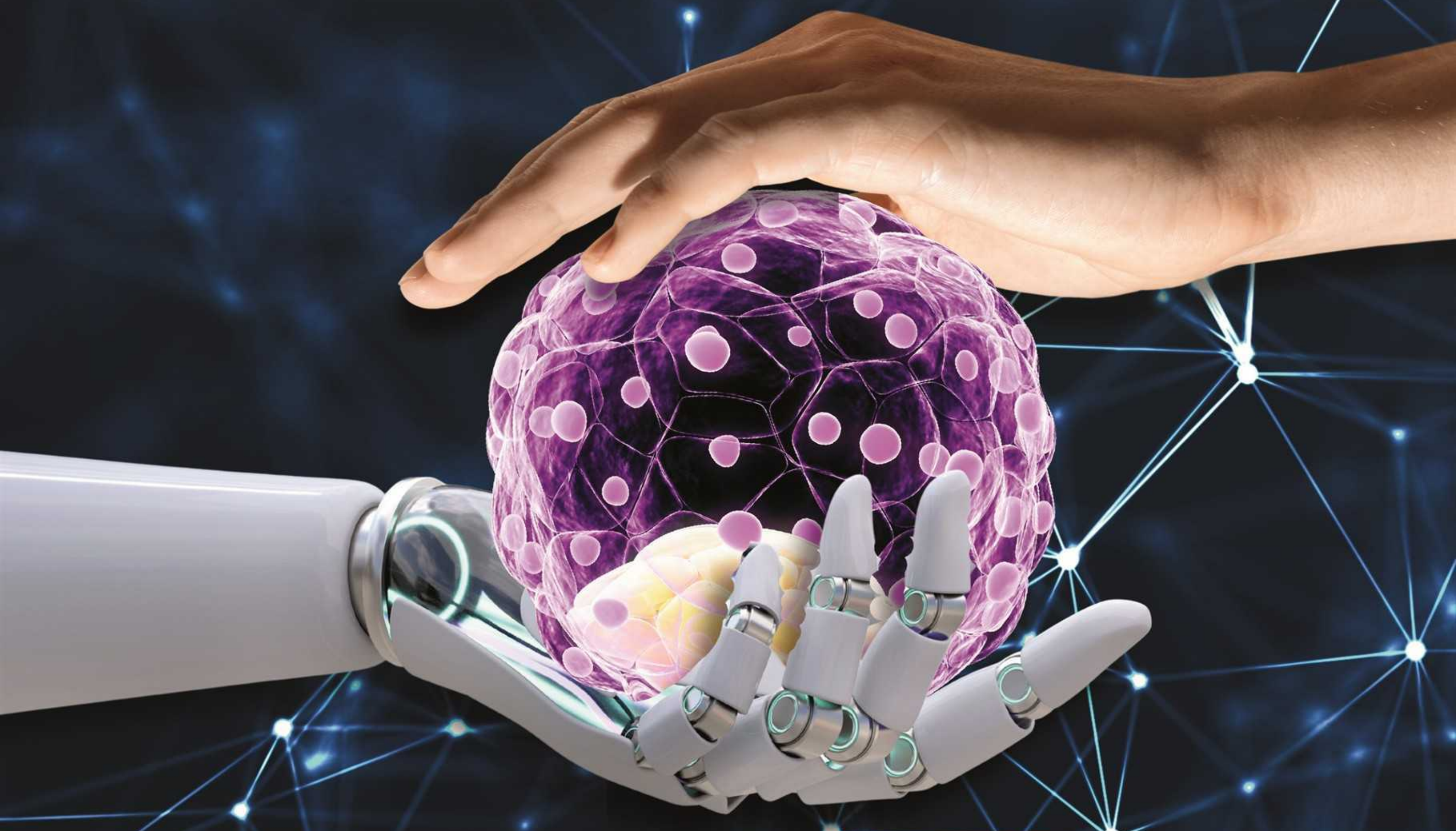
isar
Indian Society for Assisted Reproduction

The Newsletter
EXPRESS

Issue 3, August 2025

Special issue on AI in Infertility care



- AI IN OVARIAN ASSESSMENT
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30TH ANNUAL CONFERENCE OF
INDIAN SOCIETY FOR ASSISTED REPRODUCTION

30TH ISAR 2026

20, 21, 22, FEBRUARY 2026

"FROM LAB TO LIFE: MAKING ART EASIER THROUGH INNOVATIVE SCIENCE"

VENUE : THE FORUM - CONVENTION CLUB 07, OFF SP RING ROAD, SHELA, AHMEDABAD

HOSTED BY : ISAR GUJARAT CHAPTER


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Presidential Address

Artificial Intelligence in Assisted Reproduction

Dr. Ameet Patki

President, ISAR 2024-26

Esteemed colleagues, friends, and members of the ISAR family,

It is my absolute privilege and honor to pen this address for ISAR Express, as we stand at the precipice of a technological revolution that is transforming every aspect of human endeavor — including the deeply sensitive and profoundly impactful field of Assisted Reproductive Technology (ART). Today, I would like to share my thoughts on one of the most promising innovations of our time: Artificial Intelligence (AI) in assisted reproduction.

For decades, we have been perfecting the science and art of infertility treatment, constantly striving for higher success rates, safer protocols, and more patient-friendly practices. Despite significant advancements, we often encounter the complexities of human biology that make predictable outcomes elusive. Enter AI — a tool that can harness vast amounts of data, discern patterns that escape the human eye, and offer predictive capabilities that can refine and redefine ART outcomes.

Artificial intelligence is not just a buzzword anymore; it is a potent ally in enhancing decision-making in IVF clinics across the world. AI applications in ART are being explored in embryo selection, ovarian response prediction, semen analysis, and even predicting implantation success. Sophisticated algorithms can now analyze time-lapse imaging of embryos to determine developmental potential with greater accuracy than traditional morphological assessments.

Moreover, AI-driven predictive modeling is helping us customize stimulation protocols, thereby reducing patient burden and maximizing oocyte yield while maintaining safety. By utilizing large datasets and machine learning, AI helps tailor treatments to each patient's unique reproductive profile, moving us closer to the dream of truly personalized medicine.

In semen analysis, AI-based systems have demonstrated remarkable proficiency in evaluating sperm motility, morphology, and concentration with speed, precision, and reproducibility. Such advancements not only streamline laboratory workflow but also reduce observer bias, leading to more objective and consistent assessments.

Presidential Address

One of the most exciting areas is AI-assisted embryo selection. Studies have shown that AI can analyze thousands of embryonic development images, identifying subtle signs that correlate with successful pregnancies — factors that human embryologists might overlook. By combining AI insights with the expertise of embryologists, we can significantly enhance success rates.

However, while AI holds immense promise, we must approach its integration with caution and responsibility. The human touch, empathy, and clinical judgment remain irreplaceable. AI should serve as an aid — not a replacement — in making critical decisions that affect the lives of hopeful parents. Transparency in algorithms, data privacy, and ethical considerations must remain central to our discourse.

As members of ISAR, we have a responsibility to stay ahead of the curve. I urge each one of you to invest in understanding these technologies, collaborate with data scientists and AI researchers, and, most importantly, critically assess the validity and applicability of AI tools before adopting them into clinical practice.

Our vision should be clear: to harness technology not for the sake of novelty but for meaningful improvement in patient outcomes. Let us imagine a future where AI helps reduce trial and error, shortens the time to pregnancy, and makes fertility care more accessible and affordable.

At the same time, we must address the disparities that technology can bring. While urban, well-equipped centers may rapidly adopt AI-based interventions, smaller clinics might struggle. ISAR must lead the way in ensuring equitable access, training, and capacity building across the board.

In conclusion, AI in assisted reproduction is not the future — it is the present. The question is not whether we will adopt it, but how wisely and ethically we will do so. Let us embrace this transformation with open minds and vigilant hearts, ensuring that every leap forward in technology translates into hope, happiness, and life for our patients.

I thank you all for your tireless dedication to this field and for your relentless pursuit of excellence. Together, let us pioneer the next chapter of ART — one that blends the wisdom of experience with the power of artificial intelligence.

Dr. Ameet Patki
President, ISAR (2024 - 2026)

Hon. Secretary General Address

ISAR Express — Special Issue on Artificial Intelligence in Assisted Reproduction

Dr. Asha Baxi

Hon. Secretary General, ISAR

It is an absolute privilege to pen this note for a special edition of ISAR Express dedicated to Artificial Intelligence in Assisted Reproduction. The field of reproductive medicine is witnessing remarkable advancements, and AI is undoubtedly one of the most exciting frontiers. From data-driven decision-making and predictive analytics to advancements in embryo selection and laboratory precision, AI is set to revolutionize how we approach fertility care.

As the Hon. Secretary General of ISAR, I take great pride in witnessing our society invest not only in technology but also in thought leadership and knowledge sharing. This issue is a testament to ISAR's commitment to staying ahead of emerging trends and ensuring our members are well-prepared to integrate innovation into clinical practice.

I extend my sincere gratitude to the editorial team and all contributors who have worked tirelessly to curate content that is both insightful and practical. Your efforts will help clinicians and embryologists alike to understand the immense potential of AI, while also reminding us of the need to balance technology with human empathy and clinical wisdom.

As we move forward into this exciting new era, I encourage all our members to embrace these innovations with curiosity, responsibility, and a patient-centric approach.

Warm regards,

Dr. Asha Baxi
Hon. Secretary General, ISAR

From the Editor's Desk

Artificial Intelligence in Assisted Reproduction: Revolutionizing the Future of Fertility Care

Dr. Ritu Hinduja
Editor, ISAR Newsletter

Dr. Kalyani Shrimali
Co-Editor, ISAR Newsletter

It is with great excitement that I welcome you to this special edition of the Indian Society of Assisted Reproduction (ISAR) newsletter, dedicated to the transformative role of Artificial Intelligence (AI) in assisted reproduction. As we navigate the ever-evolving landscape of reproductive medicine, AI has emerged as a game-changer, offering innovative solutions to challenges once thought insurmountable.

From optimizing embryo selection to predicting treatment outcomes, AI is enhancing decision-making processes and improving success rates for patients worldwide. Machine learning algorithms now analyze vast datasets with unprecedented precision, enabling clinicians to personalize treatments like never before. These advancements promise not only to improve clinical outcomes but also to make treatments more accessible and efficient.

I would like to take this opportunity to express my heartfelt gratitude to ISAR President Dr. Ameet Patki for entrusting me with the task of compiling this newsletter. It has been an enriching experience to work on a topic as forward looking as AI in assisted reproduction. I also extend my sincere thanks to all the contributors whose valuable articles and insights have made this edition truly exceptional.

As we embrace these technological innovations, it is essential to remain grounded in our commitment to ethical practices and patient-centric care. AI is a tool—one that complements our expertise rather than replaces it. By integrating human empathy with technological precision, we can ensure that this revolution in reproductive medicine serves the best interests of patients and practitioners alike.

I hope this edition inspires you to engage with these advancements and envision how they might shape the future of our field. Together, let us innovate, collaborate, and strive for excellence as we unlock the full potential of technology in creating families and fulfilling dreams.

Warm Regards,

Dr. Ritu Hinduja, Editor, ISAR Newsletter
Dr. Kalyani Shrimali, Co-Editor, ISAR Newsletter

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Meet the **TEAM**

Dr. Charudutt Joshi

He began his career as an Embryologist in 1993 at the first IVF center in Central India, located in Indore, where he worked as a lab technician. Although he held a postgraduate degree in life sciences, he had no prior knowledge of human IVF at the time. His initial responsibilities included maintaining the cleanliness of laboratory surfaces and preparing the lab for procedures. During this period, media for IVF were prepared in-house.

In 1995, he had the opportunity to work with one of the pioneering companies supplying IVF media and disposables, gaining in-depth knowledge about media, disposables, and machinery. As new instruments were introduced by multinational companies, he received training in the UK and Germany. By this time, he had developed a strong understanding of embryology and officially became an Embryologist.

In 1998, he was appointed as the laboratory in-charge at another pioneering IVF center, where he independently managed the entire laboratory and performed ART procedures. At a time when only a few centers in India were practicing ART and knowledge-sharing was limited, he even paid to visit some laboratories to gain insights. In 2001, he underwent advanced ICSI training at Genk University in Belgium.

As IVF treatments became more widely recognized and new centers emerged, the demand for experienced embryologists increased. In 2004, he began working as a freelance Embryologist for various centers across India and internationally. He continued to expand his expertise by receiving training in cryopreservation at K.K. Women's Hospital in Singapore in 2006 and training in laser-assisted embryo biopsy in Germany in 2007. He also attended the ALPHA and ESHRE conferences twice, gaining global insights into advancements in the field.

He became an active member of several national and international societies, including ISAR, IFS, ALPHA, ACE, ASRM, and ESHRE. In 2019, he established Central India's first well-equipped ART bank, which later became the first registered ART bank under the ART Act. He contributed to the formulation of guidelines for Good Laboratory Practice (GLP) through ISAR and IFS, authored chapters in various books, and participated in numerous national and international conferences in different capacities.

His contributions to the field of ART extend to serving in various leadership roles, including:

- Executive Committee Member, ISAR Central (2016-2018, 2020-2022)
- Executive Committee Member, ISAR MP Chapter (2016-2018)
- Executive Committee Member, IFS MP Chapter (2017-2019)
- President, Academy of Clinical Embryologists (ACE) (2014-2015)
- Chairperson, ISAR Embryology (2024-2026)
- Joint Treasurer, MP ISAR (2024-2026)
- Medical Director, Genes India ART Bank, Indore
- Laboratory Director, IVF Unit, R.D. Gardi Medical College, Ujjain

With over 30 years of experience in embryology, he is dedicated to mentoring and elevating the next generation of embryologists to national and international recognition. He takes immense pride in being part of ISAR since 2000 and appreciates the society's efforts in recognizing and highlighting the contributions of embryologists.

AI IN OVARIAN ASSESSMENT

Dr. Rama Raju

Explore how artificial intelligence is reshaping fertility practices, promising improved patient success and innovative clinical advancements. Research by Dr Rama Raju and Srinivas Rao Kudavelly has resulted in series of landmark studies and clinical applications which has progressively integrated AI into reproductive medicine care cycle.

Introduction:
Artificial Intelligence (AI) is transforming reproductive medicine by enhancing precision and efficiency across key clinical workflows. By integrating advanced algorithms, AI streamlines diagnostic accuracy, optimizes treatment protocols, and improves predictive outcomes in reproductive medicine. This article highlights the transformative potential of AI in addressing challenges such as standardization and personalized care, while also discussing future directions for innovation in the field. As a disruptive force, AI promises to reshape reproductive medicine, offering unprecedented opportunities to improve patient outcomes and clinical practices.

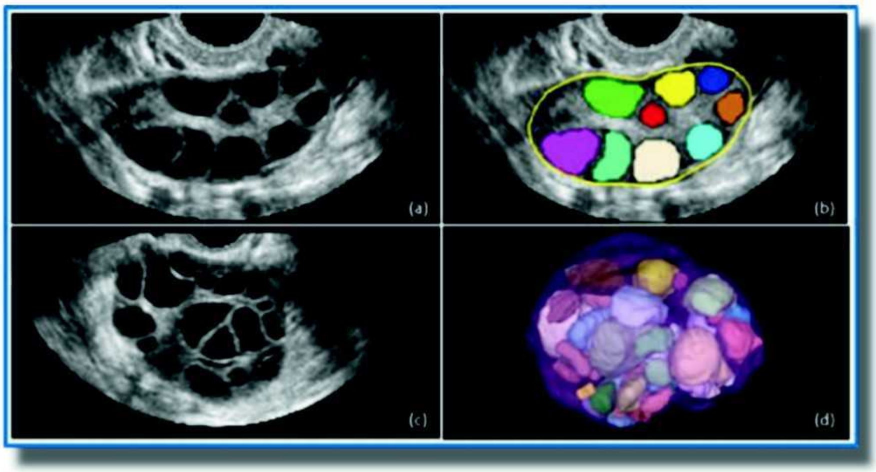
Historical Perspective: AI in Medicine:
AI's journey in medicine began with Edward H. Shortliffe, who developed MYCIN, an AI program at Stanford University in the 1970s designed for diagnosing bacterial infections and recommend antibiotics. Since then, AI has evolved through rule-based expert systems, machine learning (ML), and deep learning(DL) models that now find wide applications in reproductive medicine.

Reproductive Medicine: A Care Cycle Approach
The reproductive medicine care cycle in IVF begins with ovarian assessment to evaluate ovarian reserve (e.g., AMH levels, antral follicle count) and predict response to stimulation. Follicle tracking via ultrasound monitors follicular growth during ovarian stimulation, ensuring optimal timing for egg retrieval. Sperm analysis and scrotal evaluation assesses semen parameters (count, motility, morphology) to select viable sperm for fertilization. Post-retrieval, embryo assessment uses morphological grading to identify high-quality embryos. Junctional zone assessment evaluates endometrial receptivity by analyzing the uterine lining’s structure and contractility, often via advanced imaging, to optimize implantation timing. Finally, embryo implantation transfers the selected embryo into the uterus, followed by monitoring for successful pregnancy. This integrated IVF care provides huge opportunities for AI based applications for improved success rates at each critical stage.

AI IN OVARIAN ASSESSMENT

AI in Ovarian Assessment and Follicular Segmentation

Quantification of ovarian and follicular volume and follicle count are performed in clinical practice for diagnosis and management in assisted reproduction. Ovarian volume and Antral Follicle Count (AFC) are typically tracked over the ovulation cycle. Volumetric analysis of ovary and follicle is manual and largely operator dependent. We developed a deep-learning method for automatic simultaneous segmentation of ovary and follicles in 3D Transvaginal Ultrasound (TVUS), which has resulted in state-of-the-art results with a detection rate of 88%, 91% and 98% for follicles of size 2–4mm, 4–12mm and >12mm. Also, AI based super-resolution imaging improved the accuracy of follicle detection in 3D ultrasound scans, surpassing traditional 2D scans. This technology is crucial in diagnosing polycystic ovarian syndrome (PCOS) as per ASRM and ESHRE guidelines and poor ovarian reserves.



Ovarian & Follicular Assessment in 3D Transvaginal Ultrasound

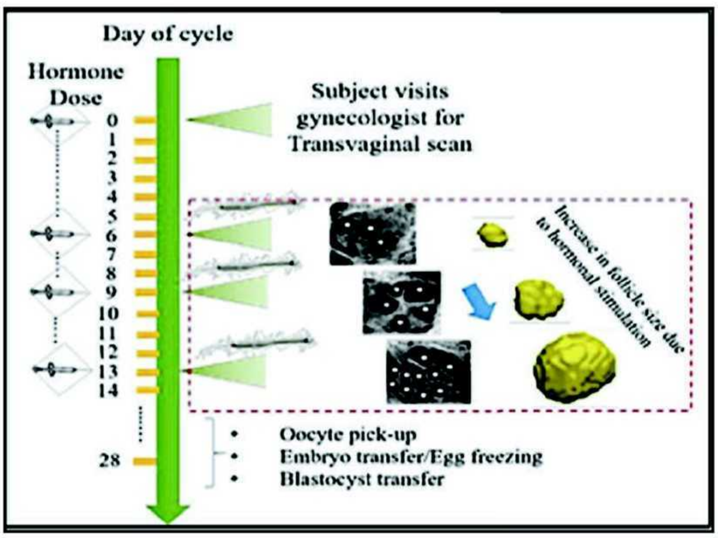
AI in Longitudinal Tracking of Follicles:

Longitudinal follicle tracking is needed in clinical practice for diagnosis and management in assisted reproduction. Follicles are tracked over the in-vitro fertilization (IVF) cycle, and this analysis is usually performed manually by a medical practitioner.

It is a challenging manual analysis and is prone to error as it is largely operator dependent.

Our AI based integrated approach of using ultrasound imaging for follicular tracking with the ovarian blood vessel mapping, enabled successful tracking of follicles above 4 mm across the IVF cycle.

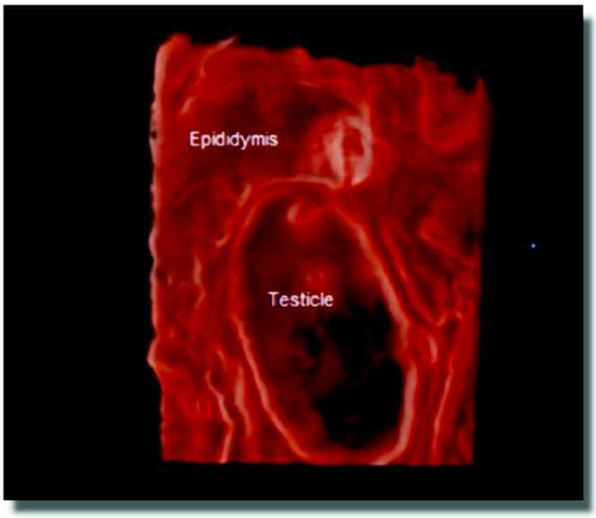
Longitudinal Follicular Growth Tracking during IVF Cycle



AI IN OVARIAN ASSESSMENT

AI in Sperm Analysis:
Sperm quality assessment is pivotal in male infertility treatment. Conventional semen analysis evaluates sperm count, motility, and morphology, but manual analysis can be subjective. Our AI based sperm analysis has been trained on large datasets to evaluate sperm motility patterns, head morphology, and DNA fragmentation. Our approach has resulted in remarkable accuracy and enhancing the precision of sperm selection for ICSI (Intracytoplasmic Sperm Injection) procedures.

AAI in Scrotal Assessment :
Scrotal abnormalities have been reported to occur in 38–65 % of infertile men, approximately 60–70% of which were not found clinically on physical examination alone. When compared to normospermic men, males with infertility have been confirmed to have significantly increased rates of scrotal findings including varicocele, hydrocele, testicular microlithiasis epididymal enlargement and epididymal cysts. An AI based automated testicular volume calculation, and epididymis volume measurements has resulted in better understanding of sperm morphology.

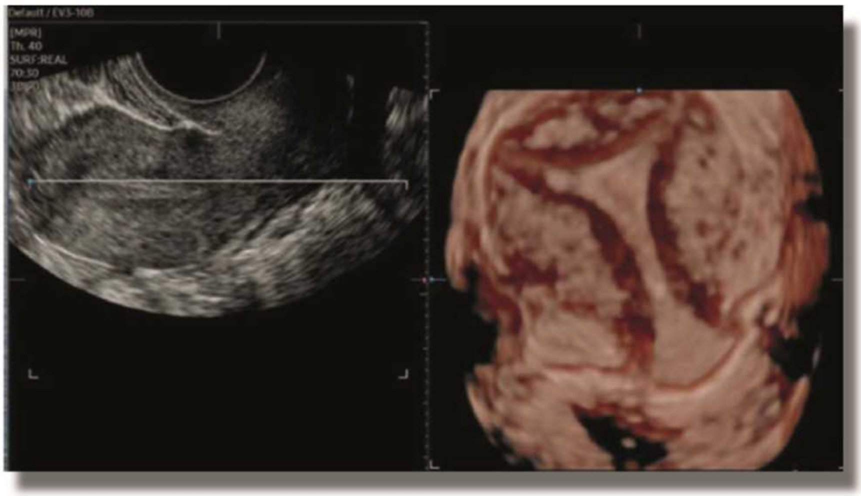


Transverse View of Testes in 3D Ultrasound

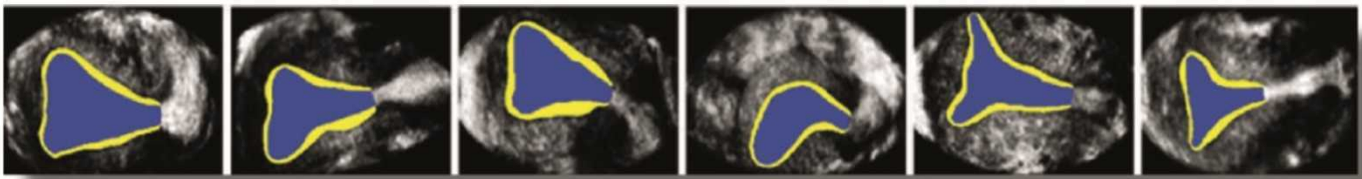
AI in Embryo Timelapse Monitoring
Embryo selection is a critical step in IVF. Traditionally, embryologists manually assess embryo viability under a microscope, but this process is prone to variability. By integrating AI based time-lapse embryo image analyzes morphokinetic parameter, such as cell division timing and blastocyst formation aiding in facilitating automated embryo grading.

AI in Uterus Junctional Zone Assessment:
The junctional zone (JZ),a layer within the myometrium, is crucial in implantation and pregnancy success. An AI-assisted analysis of the JZ has provided insights into uterine anomalies and the cesarean section niche. Serial monitoring of JZ assessment implantation outcomes highlights AI's ability to assess JZ integrity, assisting clinicians in personalized treatment planning for women undergoing IVF, thereby enhancing pregnancy success rates by optimizing embryo transfer timing.

AI IN OVARIAN ASSESSMENT



Junctional Zone is a hormone-dependent layer and appears as a hypoechoic zone around endometrial on the coronal view



Qualitative assessment of the visualization results are shown. (uterine cavityin blue and JZ in yellow)

Future Directions

AI will continue to shape reproductive medicine through

1. Robotic Guided: AI-guided robotics for automated, high-accuracy oocyte retrieval and embryo transfer.
2. Customized IVF Plans: AI tailored protocols using patient-specific biomarkers (e.g., hormonal profiles, genetic data) to optimize outcomes.
3. Predictive Success Analytics: Multifactorial AI models forecasting pregnancy likelihood, reducing emotional/financial strain via targeted interventions.
4. Endometrial Receptivity: AI-powered analysis of biomarkers (JZ, gene panels, hormonal levels) to pinpoint optimal implantation windows.
5. Tele-fertility: AI enhanced virtual platforms democratizing access to expert fertility care, particularly in resource- limited regions.

Conclusion:

AI is transforming reproductive medicine by automating complex processes, enhancing diagnostic precision, and optimizing treatment outcomes. The successful implementation of AI in reproductive medicine necessitates collaborative efforts involving AI developers, clinicians, and regulatory authorities.

Each stakeholder has a vital role in ensuring the ethical, efficient, and patient-centered application of AI within the field.

THE ROLE OF AI IN FERTILITY DIAGNOSIS

Dr. Markus Nitzschke

Dr. Sheetal Sawankar

Abstract

The incidence of infertility is continuously increasing nearly all over the world in recent years, and novel methods for accurate assessment are of great need. The application of Artificial Intelligence (AI) in fertility diagnosis has revolutionized the field of reproductive medicine. It has been used in clinical follicular monitoring, optimum timing for transplantation, and prediction of pregnancy outcome.

This chapter explores the transformative impact of AI technologies on the diagnosis and treatment of fertility issues, particularly focusing on advancements made over the past two decades. AI's integration in fertility clinics has enhanced diagnostic accuracy, streamlined processes, and improved patient outcomes. This chapter reviews existing literature, discusses the significant contributions of AI in this domain, and outlines future directions for its application in fertility diagnosis.

Introduction

The journey to parenthood can be fraught with challenges, and for many, fertility issues present significant hurdles. Traditional methods of diagnosing and treating infertility, while effective, have limitations in accuracy and efficiency. The advent of Artificial Intelligence (AI) has introduced new possibilities for improving fertility diagnosis.

Over the past few years, AI was regarded as an efficient and reliable method to aid diagnosis, treatment, and prognosis in the medical field, especially after the breakthrough of medical big data analysis and management. [1,2]

Currently, AI is currently being tested in several areas of reproductive medicine, including sperm identification and morphology, automatic embryo cell stage prediction, embryo evaluation, and prediction of live birth, as well as the development of improved stimulation protocols.[3,4] Ultrasound in reproductive medicine, like other disciplines, has been constantly improved by the advances of AI technology.

AI's ability to analyse vast amounts of data quickly and accurately offers unprecedented opportunities to enhance the precision of fertility assessments, tailor treatments to individual patients, and ultimately improve success rates.

Review of Literature

Early Developments in AI and Fertility Diagnosis

Artificial intelligence in medicine means dealing with the prevention, diagnosis, and cure of diseases through knowledge- and/or data-intensive computer-based solutions.[5] The initial integration of AI in medicine focused on data analysis and pattern recognition. In the late 20th and early 21st centuries, researchers began exploring AI's potential in reproductive health. Early studies demonstrated AI's ability to assist in diagnosing conditions such as polycystic ovary syndrome (PCOS) and endometriosis through pattern recognition in ultrasound and MRI images Analysis

THE ROLE OF AI IN FERTILITY DIAGNOSIS

One of the significant breakthroughs in AI application was in predictive analysis for in vitro fertilization (IVF) outcomes. Studies from the early 2000s showed that machine learning algorithms could predict IVF success rates based on patient data, including age, hormone levels, and previous treatment outcomes.
For algorithm methods, Figure 1 shows the relationship among artificial intelligence, machine learning, and deep learning. Machine learning is a sub-field of artificial intelligence, which consists primarily of traditional machine learning methods (such as regression, decision tree, random forest, naïve Bayes and support vector machine, etc.) and deep learning algorithms (such as convolutional neural network, recurrent neural network, etc.).

These models give valuable insights, allowing for more personalized treatment plans.

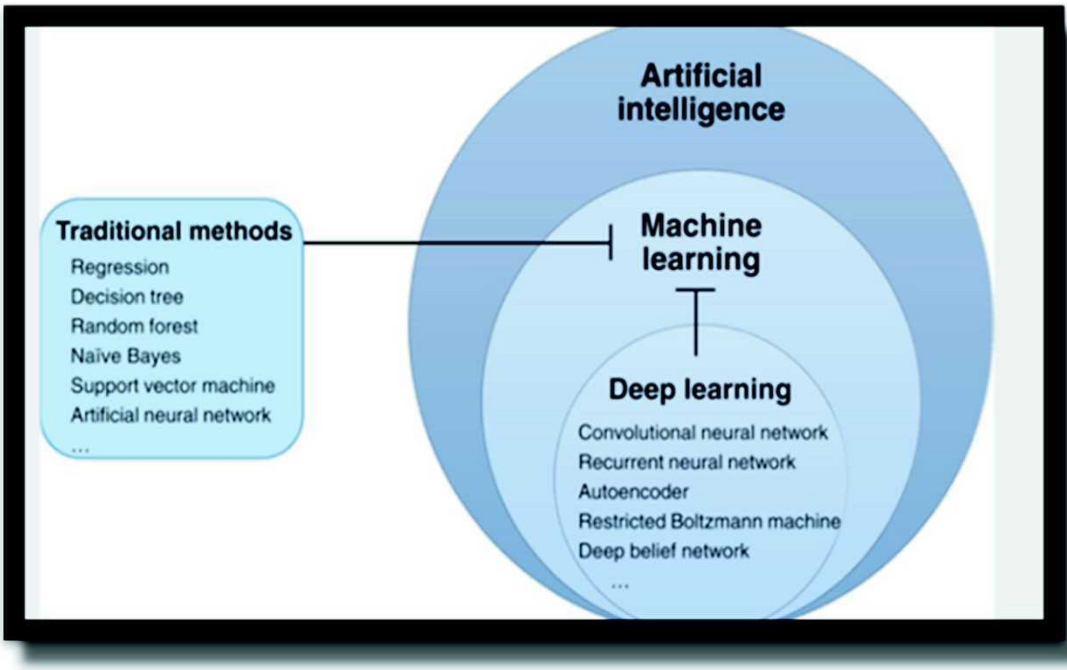


FIGURE 1- Relationship among artificial intelligence, machine learning and deep learning. [6]

Role of AI in the Diagnosis of Female Fertility

The integration of Artificial Intelligence (AI) into reproductive medicine has revolutionized the diagnosis and management of female infertility. AI tools, with their ability to analyse vast datasets, are enhancing the precision of fertility diagnostics by identifying patterns and biomarkers that might be overlooked by human interpretation.

1. Predicting Ovarian Reserve and Response:
AI algorithms have demonstrated significant potential in assessing ovarian reserve by analysing markers like Anti-Müllerian Hormone (AMH) levels and antral follicle counts. By integrating patient history, ultrasound images, and laboratory data, AI can predict ovarian response to stimulation with higher accuracy [7]

2. Endometrial Receptivity Analysis:
AI has been used to evaluate endometrial receptivity by analysing histopathological images and gene expression profiles. These models predict the optimal window for implantation, aiding in personalized embryo transfer timing [8]

3. PCOS and Endometriosis Diagnosis:
Machine learning models have been effective in diagnosing complex conditions like Polycystic Ovary Syndrome (PCOS) and endometriosis. AI systems analyse data from ultrasound images and hormonal assays to differentiate these conditions with high specificity and sensitivity [9]

4. Automated Imaging Analysis:
AI-powered image recognition tools assist in the analysis of ultrasound and hysterosalpingography (HSG) images. For instance, deep learning algorithms can identify uterine anomalies, such as fibroids or polyps, with precision, reducing the dependency on subjective human expertise [10]
Advances in Imaging and Diagnostics
AI has significantly enhanced imaging techniques used in fertility diagnosis. Convolutional neural networks (CNNs) have been employed to analyse ultrasound images, improving the detection of ovarian and uterine abnormalities.
The first step for the diagnosis and treatment of infertility is to understand the ovarian status and follicle monitoring. Since the demand for ART and follicular monitoring is great, AI-aided ultrasound for the detection of follicles is necessary. Optimal thresholding, edge-based method, watershed transformation, scanline thresholding, and active contour method were typical algorithms in ovarian follicular boundary segmentation. [11] In Rose's study, follicles were detected by performing different segmentation techniques depending on features of the image (such as pixel intensity level) and features of the areas of detected follicles (such as roundness) to automatic detection of follicles.[12] Studies have shown that AI can match or surpass human experts in identifying subtle features indicative of fertility issues

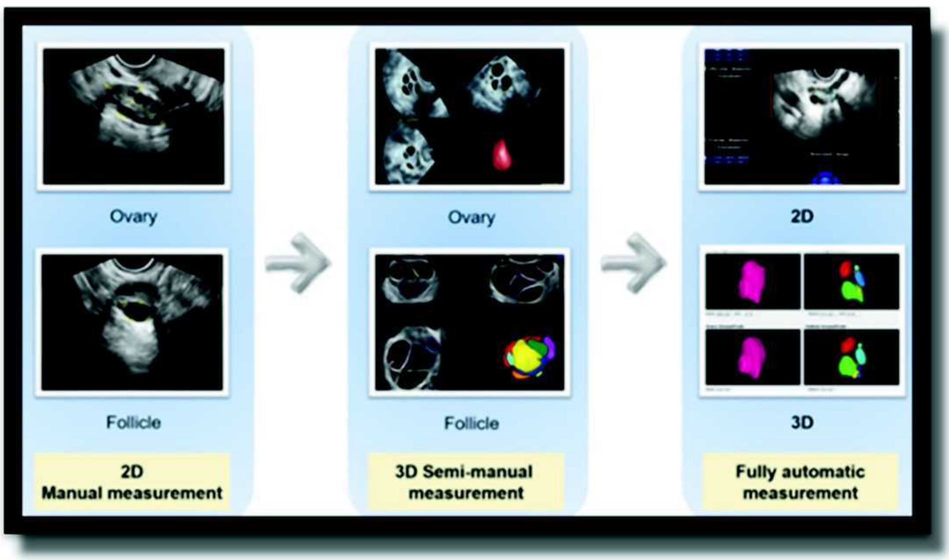


FIG 2- Advanced ultrasound techniques in follicular monitoring.

5. Enhancing Diagnostic Timelines:
The speed and efficiency of AI in processing large datasets allow for quicker diagnostic timelines. For instance, AI-based platforms can instantly analyse hormonal profiles, imaging, and clinical history, offering actionable insights in real-time [13](Huang et al., 2021).

AI in Male infertility

Artificial Intelligence (AI) has emerged as a transformative tool in diagnosing male infertility. By leveraging machine learning (ML) algorithms and deep learning models, AI enhances the accuracy, speed, and objectivity of infertility assessments. AI-powered systems analyse semen parameters like sperm concentration, motility, and morphology with higher precision than conventional methods [14]. Automated semen analysis tools reduce inter-observer variability, ensuring consistent and reliable results.
Moreover, AI aids in detecting subtle sperm anomalies through image recognition technologies, which might be overlooked by manual evaluation [15]. Genetic and proteomic data integration through AI models enables identification of underlying molecular causes of infertility, facilitating personalized treatment plans. Predictive algorithms also help in evaluating the success rates of assisted reproductive techniques, optimizing patient care [16]
Despite its potential, challenges such as data standardization, regulatory approvals, and ethical considerations need to be addressed to fully integrate AI into clinical practice. Nevertheless, AI holds promise to revolutionize male infertility diagnosis by providing cost-effective, scalable, and precise solutions.

Integration with Electronic Health Records (EHRs)

The integration of AI with EHRs has streamlined the diagnostic process. AI systems can quickly review patient histories, identify relevant patterns, and suggest potential diagnoses. This has been particularly beneficial in identifying less obvious causes of infertility, such as underlying medical conditions or lifestyle factors .

Discussion

Benefits of AI in Fertility Diagnosis

AI has an ability to process and analyse large datasets with speed and precision. In fertility diagnosis, this capability translates to more accurate assessments and better-informed treatment decisions. AI-driven tools have reduced the time required for diagnostic procedures and minimized human error, leading to higher success rates in fertility treatments.

Personalized Treatment Plans

AI enables the development of highly personalized treatment plans. By analysing a patient's unique data, AI can predict how they might respond to different treatment options. This individualized approach increases the likelihood of successful outcomes and reduces the physical and emotional strain on patients undergoing fertility treatments

THE ROLE OF AI IN FERTILITY DIAGNOSIS

Enhanced Imaging and Diagnostic Accuracy

AI-powered imaging technologies have improved the diagnostic accuracy. CNNs and other deep learning models can identify minute details in imaging studies that may be overlooked by human eyes. This capability is crucial in diagnosing conditions such as PCOS, endometriosis, and other structural abnormalities affecting fertility .

Integration with EHRs

The seamless integration of AI with EHRs has enhanced the efficiency of fertility clinics. AI analyses patient records, providing clinicians with comprehensive insights into a patient's medical history. This holistic view facilitates more accurate diagnoses and better treatment outcomes .

Challenges and Ethical Considerations

Despite its benefits, the use of AI in fertility diagnosis is not without challenges. One major concern bias in AI algorithms is if the data used to train these algorithms is not representative of the diverse patient population, the results may be skewed, leading to disparities in care .

Data Privacy and Security

The use of AI in healthcare raises significant concerns about data privacy and security. Ensuring that patient data is protected from bed access is paramount. Robust security measures and strict regulatory frameworks are essential to maintain patient trust and confidentiality .

Ethical Implications

The ethical implications of AI in fertility diagnosis are complex. Issues such as the potential for over-reliance on AI, the need for human oversight, must be carefully considered. Establishing ethical guidelines and ensuring transparency in AI applications is critical to addressing these concerns .

Conclusion

The role of AI in fertility diagnosis represents a significant advancement in reproductive medicine. AI technologies have enhanced diagnostic accuracy, personalized treatment plans, and improved pregnancy outcomes. AI will not replace reproductive medicine practitioners, sonographers, and embryologists, but rather, will streamline their efforts with the goal of better helping their patients. Despite the challenges of application, with the standardized development of technology and the medical industry, AI will assist in the conduct of individualized treatment through the holistic medical information of patients, and its application has unlimited potential for development. As AI continues to evolve, its potential to transform fertility diagnosis and treatment remains immense, promising a future where more individuals can achieve their dream of parenthood.

AI POWERED EMBRYO SELECTION

Dr. Fabrizzio Horta

Dr. Keshav Malhotra

Introduction

Embryo selection is the cornerstone of successful in vitro fertilization (IVF), yet current practices fall short of guaranteeing consistent outcomes. Despite the growing demand for assisted reproductive technologies, global IVF success rates remain below 30%, with women over 42 experiencing even lower odds. This gap has spurred interest in innovative solutions such as Artificial Intelligence (AI), a technology that is already reshaping healthcare. In the realm of IVF, AI is emerging as a technology aiming to enhance the accuracy, objectivity, and efficiency of embryo selection. In this article, we explore findings from a comprehensive systematic review to understand how AI compares to traditional methods and its potential to revolutionize embryology.

Traditional Challenges in Embryo Selection

Embryo selection traditionally depends on visual assessments of morphology and developmental milestones, supplemented by preimplantation genetic testing (PGT). These methods, while valuable, are prone to variability due to human subjectivity and limited by the invasiveness and cost of genetic screening. Embryologists must weigh numerous factors—from cellular symmetry to cleavage rates—to estimate viability. Unfortunately, despite strong efforts in trying to adopt standardized criteria for embryo selection, current practice often leads to inconsistent decisions between embryologists, leaving significant room for improvement. This is where AI steps in with its promise of precision and reproducibility.

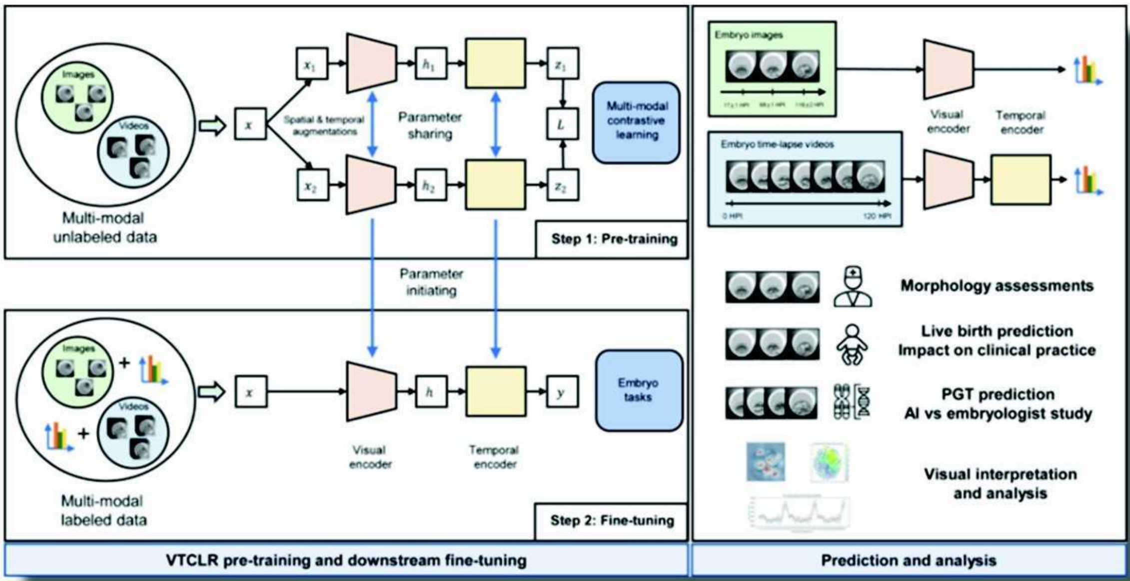
How AI-Based Systems Work

AI-based systems for embryo selection use advanced machine learning algorithms to analyze data inputs such as images, time-lapse videos, and clinical information. Here's how they operate:

1. **Image Processing:** AI systems have primarily used convolutional neural networks (CNNs) to process images of embryos at different developmental stages. They recognise features and patterns of images pixel by pixel, allowing AI system learning to identify cellular morphology, symmetry, and division patterns, which are often too subtle for the human eye to detect.
2. **Time-Lapse Analysis:** Time-lapse imaging provides continuous data on embryo development AI models use this data to identify optimal growth trajectories and pinpoint anomalies that could impact implantation potential. Similarly, AI systems have been developed to link this data with clinical outcomes such as clinical pregnancy.

3. Integration of Clinical Data: Some systems incorporate patient-specific information, such as age, hormonal profiles, and medical history, to provide a more personalized prediction of embryo viability and success rates.
4. Predictive Modeling: By training on large datasets, AI algorithms learn to correlate specific features with clinical outcomes, such as implantation success, clinical pregnancy or live birth rates. This training enables the models to predict outcomes with high accuracy.
5. Decision Support: AI systems present their analyses in an interpretable format, offering embryologists actionable insights while maintaining their role in the decision-making process.

Studies included in the systematic review demonstrated that AI-based systems often surpass traditional methods. For example, models achieved up to 98% accuracy in predicting viable embryos, compared to human accuracy rates of 53-76%.



AI-Based Software Tools for Embryo Selection

Several AI-based software tools have been developed to assist in embryo selection. Here are some of the most prominent ones and their usage:

1. **Eeva™ System (Early Embryo Viability Assessment)**
   - **Functionality:** Uses time-lapse imaging and AI to assess embryo development and predict viability.
   - **How to Use:** Integrates with existing time-lapse imaging systems. Embryologists review the AI-generated rankings to select the most viable embryos for transfer.
2. **ERICA (Embryo Ranking Intelligent Classification Algorithm)**
   - **Functionality:** Predicts embryo ploidy and implantation potential using deep learning.
   - **How to Use:** Requires integration with clinic-specific imaging and patient databases. Outputs rankings based on viability and genetic health.

3. IVF 2.0 by Presagen

- **Functionality:** Provides predictive analytics by combining image analysis with clinical data.
- **How to Use:** Input patient history and embryo imaging data into the platform for a comprehensive report on embryo viability.

4. EmbryoScope+ IdaScore

- **Functionality:** Offers continuous time-lapse monitoring and AI-driven analysis of embryo development.
- **How to Use:** Embryos are cultured in the EmbryoScope incubator, and the system provides real-time insights into their development for selection decisions.

AI in Embryology: Key Innovations

Artificial Intelligence leverages machine learning algorithms to analyze complex datasets, including images, time-lapse videos, and patient-specific clinical data. Unlike human assessments, AI systems can identify subtle markers of viability that are invisible to the naked eye. The systematic review highlighted several AI technologies revolutionizing embryo selection:

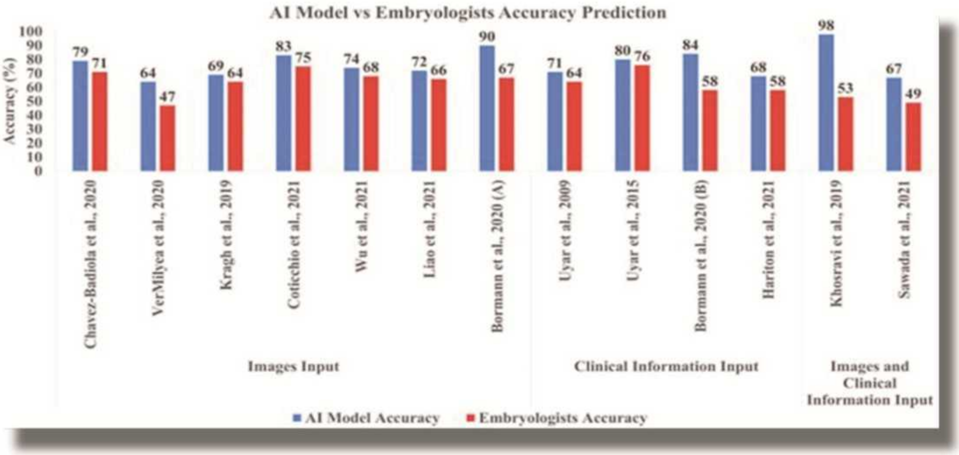
- Convolutional Neural Networks (CNNs): These models excel at analyzing pixel-level image data, predicting outcomes such as blastocyst quality with impressive accuracy.
- Integrated Models: Combining images with clinical information, these systems offer personalized predictions tailored to patient profiles.
- Real-Time Decision Tools: AI-driven platforms provide actionable insights during critical stages of IVF, aiding embryologists in making informed choices.

In the studies analyzed, AI models achieved median accuracies of 77.8% for clinical pregnancy predictions and 81.5% when integrating both images and clinical data, outperforming embryologists by significant margins.

How AI Outperforms Human Embryologists

1. **Enhanced Accuracy:** AI systems consistently demonstrate higher accuracy in embryo grading and predicting clinical outcomes. Systematic review by Salih et al 2023 reported that AI achieved up to 98% accuracy in certain studies, compared to human accuracy rates ranging from 53% to 76%.
2. **Objectivity:** AI eliminates the variability inherent in human assessments, standardizing evaluations across different clinics and practitioners.
3. **Efficiency:** By automating repetitive tasks like image analysis, AI frees up embryologists to focus on complex clinical decisions and patient care.
4. **Scalability:** With sufficient training datasets, AI systems can be deployed globally, democratizing access to high-quality embryo evaluation.

AI POWERED EMBRYO SELECTION



Ethical and Practical Considerations

The integration of AI in embryology is not without challenges. Key issues include:

- Bias in AI Models: Training data often reflects local patient populations, limiting the generalizability of AI systems to diverse ethnic and demographic groups.
- Transparency and Trust: Patients and clinicians may question the "black box" nature of AI decisions, necessitating clear explanations of AI-driven recommendations.
- Regulatory Hurdles: AI tools must meet stringent validation requirements to gain acceptance in clinical settings.
- Cost and Accessibility: Initial implementation costs could hinder adoption in resource-constrained environments.

Addressing these concerns will require robust collaborations among developers, clinicians, and policymakers to ensure ethical deployment.

The Path Forward: AI's Expanding Role in IVF

The future of AI in IVF extends beyond embryo selection. Emerging trends include:

- Multi-Omics Integration: By incorporating genetic, proteomic, and metabolomic data, AI could offer holistic assessments of embryo viability.
- Predictive Analytics for Personalized Care: AI systems could recommend tailored IVF protocols based on patient history, optimizing outcomes.
- Real-Time Feedback Loops: Continuous learning models will adapt to new data, enhancing their predictive power over time.

While clinical validation remains a critical next step, early results suggest that AI has the potential to redefine reproductive medicine, making IVF more accessible and successful. Current systems could certainly allow improve the efficiency of IVF process such embryo selection, however, improvements in clinical outcomes remind to be demonstrated.

Conclusion

The systematic review underscores AI's transformative potential in embryo selection, offering improvements in accuracy and efficiency for embryo selection. However, its success hinges on overcoming ethical, technical, and logistical challenges. By fostering interdisciplinary collaboration and prioritizing patient-centered care, the field of embryology can harness AI's capabilities to improve outcomes and reduce the emotional and financial burdens of infertility. As technology and medicine converge, AI stands poised to make IVF a more reliable option for hopeful parents worldwide.

ARTIFICIAL INTELLIGENCE IN MALE INFERTILITY

Dr. Matt Tomlinson

Dr. Nishad Chimote

Abstract

Semen analysis is a cornerstone of male fertility assessment, offering crucial insights into sperm concentration, motility, and morphology. Historically, manual microscopic evaluation has been the gold standard, though it is prone to inter-observer variability and labour-intensive processes. The advent of automation and artificial intelligence (AI) has introduced new methodologies aimed at improving accuracy, efficiency, and reproducibility. This review examines the evolution of semen analysis, the impact of automation, and AI-driven methodologies. Furthermore, we analyse comparative data from manual, CASA, and AI-based approaches, discuss their applicability in various clinical settings, and critically evaluate whether AI-based systems are ready for widespread adoption. Additionally, we explore the **specific challenges and advantages of AI adoption in the Indian healthcare system**, considering the **high patient volumes in urban fertility centres, batch IVF setups, and small clinics with limited resources.**

Introduction:

In 2021, the global IVF market surpassed $25 billion, yet the evaluation of male fertility—a critical pillar of reproductive success—remains tethered to manual methods unchanged since the 1950s. Semen analysis, the cornerstone of male infertility diagnostics, is riddled with subjectivity, inefficiency, and alarming inter-laboratory variability (30–40%) even in WHO-accredited centers. While automation and artificial intelligence (AI) promise to revolutionize this field, their adoption has been uneven, particularly in resource-heterogeneous settings like India. This article critically examines the **specific challenges and advantages of AI adoption in the Indian healthcare system,** including high patient volumes in urban fertility centers, batch IVF setups, and small clinics with limited resources, while juxtaposing these realities against global advancements. All data is rigorously referenced to ensure scholarly integrity.

The Evolution of Semen Analysis: A Journey from Subjectivity to Standardization

1. Manual Microscopy: The Persistent Gold Standard

Manual semen analysis, despite its flaws, remains the global benchmark. Technicians assess sperm concentration, motility, and morphology under phase-contrast microscopy, but studies reveal:

- **Motility Overestimation:** Prolonged observation inflates counts by 15–20% due to the inability to track sperm leaving the microscopic field (Tomlinson, 2016).
- **Morphology Discordance:** Inter-observer variability reaches 40% using Kruger's "strict criteria," a metric derived from homogeneous populations with questionable clinical relevance (Van der Hoven et al., 2014).
- **Time Burden:** 40–60 minutes per sample, untenable for clinics handling 50+ daily cases.

2. CASA: From Flawed Beginnings to Modern Relevance

The introduction of Computer-Assisted Sperm Analysis (CASA) in the late 1980s marked a pivotal shift toward automation in semen analysis. Early systems, however, were plagued by technical limitations that hindered widespread adoption. A primary challenge was their inability to reliably distinguish sperm from non-sperm particles, such as leukocytes, epithelial cells, or debris, leading to inflated concentration estimates (Barratt et al., 1992). Additionally, early CASA software focused excessively on kinematic parameters—such as lateral head displacement, linearity, and curvilinear velocity—which lacked clinical correlation with fertility outcomes (Oehninger et al., 2000). These metrics, while mathematically precise, failed to translate into actionable diagnostic insights, creating skepticism among clinicians.

Over the past decade, advancements in imaging technology and machine learning algorithms have revitalized CASA's role in modern andrology. Contemporary systems, such as the **CEROS II** and **SQA-V Gold,** now integrate high-resolution phase-contrast microscopy with enhanced object-recognition algorithms, significantly improving debris differentiation (Lammers et al., 2014). For instance, a 2020 validation study demonstrated that modern CASA systems achieve 92% concordance with manual counts in oligozoospermic samples (sperm concentration <15 million/mL), a marked improvement from the 70% accuracy of early models (Tomlinson et al., 2018). Furthermore, the adoption of standardized video capture protocols (e.g., 30–60 frames per second) and user-friendly interfaces has reduced inter-laboratory variability in motility assessments from 25% to <10% (Bellastella et al., 2010).

Today, CASA is no longer a fringe technology but a complementary tool in high-throughput laboratories. Its ability to archive video recordings for retrospective analysis has proven invaluable for quality assurance and training, while semi-automated morphology modules now allow technicians to overlay AI-generated morphometric grids on sperm images, enhancing precision (Tomlinson & Naeem, 2018). Nevertheless, CASA remains a bridge rather than a destination—its dependence on manual verification for morphology underscores the need for more advanced solutions.

3. AI: The New Frontier

Modern AI platforms like **LensHooke X1 Pro** and **YOOSperm** use deep learning to analyze sperm videos frame-by-frame, achieving:

- **Rapid Processing:** 3 minutes per sample vs. 40 minutes manually.
- **Quantitative Metrics:** Motility tracks sperm trajectories; morphology quantifies head elongation (L/W >1.8) and vacuoles.
- **Scalability:** Ideal for high-volume clinics processing 100+ samples daily.

Comparative Analysis of Semen Analysis Methods: Insights from Clinical Data

The efficacy of semen analysis methodologies is best illustrated through comparative data. **Chart 1** juxtaposes key parameters—sperm concentration, progressive motility, total motility, and normal morphology—across manual, CASA and AI-driven platforms (LensHooke X1 Pro and SQA-V Gold).

Chart 1: Comparative Analysis of Semen Analysis Methods

Parameter	Manual	CASA (CEROS)	SQA-V Gold	LensHooke X1 Pro
Sperm Concentration	28.1 M/mL	32.0 M/mL	32.6 M/mL	33.5 M/mL
Progressive Motility	40.6%	40.8%	40.1%	45.3%
Total Motility	58.3%	57.0%	54.7%	62.8%
Normal Morphology	7.0%	5.0%	10.6%	9.5%

CEROS -II

SQA-V Gold

LensHooke X1 Pro

Interpretation: Data has been compiled from the following published articles :Double-blind prospective study comparing two automated sperm analyzers versus manual semen assessment2014 Jan;31(1):35-43. doi: 10.1007/s10815-013-0139-2. Epub 2013 Nov 16. Agarwal, A., Selvam, M.K.P. and Ambar, R.F. (2021) 'Validation of LensHooke® X1 PRO and computer-assisted semen analyzer compared with laboratory-based manual semen analysis', World Journal of Men's Health, 39(3), pp. 496–505. doi: 10.5534/wjmh.200185.

- **Sperm Concentration:** CASA and AI systems report higher concentrations than manual methods (+12–15%), likely due to automated counting reducing human error in grid-based hemocytometer assessments. However, this raises concerns about debris misclassification, particularly in samples with high particulate content.
- **Motility Metrics:** While CASA aligns closely with manual assessments for progressive motility (40.8% vs. 40.6%), AI platforms like LensHooke X1 Pro report inflated values (45.3%), attributed to algorithmic inclusion of borderline motile sperm.
- **Morphology:** The disparity between methods is stark. Manual assessments classify 7% of sperm as normal, whereas CASA underestimates (5%) and spectrophotometric systems (SQA-V Gold) overestimate (10.6%). AI platforms strike a middle ground (9.5%), reflecting improved consistency but not absolute accuracy.

Chart 2: Processing Time Comparison

Method	Processing Time (Minutes)
Manual Analysis	40
CASA CEROS	15
SQA-V Gold	5
LensHooke X1 Pro	3

Interpretation:

- **Manual Analysis** remains the most time-intensive (40 minutes/sample), requiring meticulous microscopy and manual tallying.
- **CASA** reduces processing time by 60% (15 minutes), primarily by automating sperm tracking and count calculation.
- **AI-Driven Systems** (e.g., LensHooke X1 Pro) slash time further (3 minutes), leveraging batch processing and eliminating manual input.

AI in the Indian Context: High Hopes and Hard Realities

1. Urban High-Volume Centres: The Batch IVF Model

India's urban fertility hubs, such as Mumbai and Delhi, perform **12,000+ IVF cycles annually** (ICMR, 2021). These centres operate on a "batch IVF" model, processing dozens of semen samples simultaneously. Here, AI's value is undeniable:

- **Scalability:** AI reduces analysis time by 90%, enabling technicians to focus on high-risk tasks (e.g., sperm preparation).
- **Hybrid Workflows:** AI screens for concentration/motility, while embryologists validate morphology, minimizing errors (Gupta et al., 2023).

2. Risk and Staff Efficiency

The shift toward automation addresses critical risks inherent in manual methods. Identity mix-ups, a harrowing reality in high-volume labs, are mitigated through AI's digital tracking systems, which tag samples with barcodes and timestamps (Tomlinson, 2016). Staff efficiency improves as technicians transition from repetitive tasks like sperm counting to roles requiring clinical judgment, such as correlating semen parameters with patient history. For example, a Mumbai-based study found that AI adoption reduced procedural errors by 40% and allowed embryologists to reallocate 15 hours weekly to patient counselling (Gupta et al., 2023).

3. Rural and Small Clinics: Resource Barriers

In contrast, small clinics face stark challenges:

- **Infrastructure Gaps:** Intermittent electricity and poor internet hinder cloud-based AI solutions.
- **Skill Shortages:** Technicians in rural areas often lack training to operate advanced systems.

4. Algorithmic Bias: A Hidden Inequity

Western-trained AI models underperform in Indian populations due to morphological disparities:

- **Pyriform Heads:** Prevalence of 18% in Indian sperm vs. 9% in Caucasians (Kumar et al., 2020)
- **Validation Deficits:** A 2023 Chennai study found AI misclassified 22% of morphologically normal sperm due to training biases, underscoring the need for region-specific datasets (Gupta et al., 2023).

What Can AI or Automation Do for Andrology? A Global Perspective

1. Standardization Beyond Borders

AI eliminates human subjectivity, offering reproducible results across diverse settings. For instance, a patient in Mumbai and another in Boston receive identical diagnostic rigor, a feat unattainable with manual methods.

2. Predictive Power: Beyond Descriptive Metrics

AI's potential extends to predictive analytics:

- **Fertility Prognostication:** Correlating sperm DNA fragmentation with motility patterns to forecast ICSI success (Majzoub et al., 2019).
- **Toxicology Insights:** Detecting subclinical motility changes in sperm exposed to pollutants (e.g., PM2.5).

3. Ethical and Technical Imperatives

- **Explainable AI (XAI):** Demystifying "black-box" algorithms to build clinician trust (Chen et al., 2023).
- **Regulatory Frameworks:** WHO-endorsed guidelines for validating AI tools, mirroring the EU's IVDR standards.

Conclusion: Redefining Andrology Through AI and Automation—Opportunities & Imperatives

The integration of automation and artificial intelligence into semen analysis heralds a transformative era for andrology, one that transcends the limitations of manual methodologies while posing critical questions about equity, validation, and clinical responsibility. AI's capacity to standardize diagnostics—ensuring that a patient in Mumbai receives the same rigorous assessment as one in Boston—addresses decades of inter-laboratory variability and subjective interpretation. By automating sperm concentration and motility assessments, AI liberates technicians from time-intensive tasks, allowing them to focus on high-risk procedures such as sperm preparation for ICSI or addressing complex morphological ambiguities. This shift not only enhances staff efficiency but also mitigates risks associated with human error, such as identity mix-ups or misclassification, which remain pressing concerns in high-volume IVF settings.

However, the promise of AI must be tempered with pragmatism. While platforms like LensHooke X1 Pro reduce processing times to mere minutes and offer predictive insights into sperm DNA fragmentation or environmental toxicology, their propensity to overestimate motility and morphology underscores the irreplaceable role of human expertise. Hybrid models, where AI handles preliminary screening and embryologists validate outcomes, strike a balance between efficiency and accuracy, particularly in India's bustling urban centres like Mumbai and Delhi, where batch IVF models dominate. In resource-limited rural clinics, however, the high costs of advanced AI systems and infrastructural gaps—such as unreliable electricity or internet—demand interim solutions, such as subsidized CASA devices or tele-andrology platforms that enable remote semen analysis.

Ethical imperatives loom large. The underperformance of Western-trained AI algorithms in non-Caucasian populations, as evidenced by the 22% misclassification rate in Indian sperm morphology (Gupta et al., 2023), highlights the urgent need for region-specific training datasets and transparent, explainable AI frameworks. Regulatory bodies must collaborate with clinicians and developers to establish validation protocols akin to the EU's IVDR, ensuring that AI tools are both clinically robust and culturally competent.

Ultimately, AI and automation are not replacements for human judgment but tools to augment it. The future of andrology lies in a synergistic model where machine precision enhances diagnostic reproducibility, while clinicians focus on nuanced decision-making and patient-centric care. For this vision to materialize, stakeholders must prioritize equitable access, algorithmic accountability, and continuous education—ensuring that the benefits of innovation extend beyond urban hubs to every corner of the globe, including India's underserved clinics. In doing so, semen analysis will evolve from a static diagnostic test into a dynamic pillar of personalized reproductive medicine.

AI-ASSISTED EVALUATION OF OVARIAN RESERVE AND IVF SUCCESS

Dr Rohan Palshetkar

Introduction

Ovarian reserve, defined as the number and quality of eggs within a woman's ovaries, is a critical factor in determining reproductive potential. For individuals undergoing assisted reproductive technologies (ART) such as in-vitro fertilization (IVF), evaluating ovarian reserve is essential for predicting fertility outcomes and planning treatments. Conventional methods like Anti-Müllerian Hormone (AMH) levels, Antral Follicle Count (AFC), and basal follicle-stimulating hormone (FSH) have long been standard tools for this purpose. However, these approaches often suffer from inter-observer variability, fluctuating results, and challenges in analyzing large, multifaceted datasets (Smith et al. 23).

Artificial intelligence (AI) is transforming reproductive medicine by offering tools to standardize and enhance ovarian reserve assessments. AI systems can integrate data from diverse sources, such as hormonal profiles, ultrasound imaging, and demographic information, to provide accurate and individualized predictions. Research shows that AI models outperform traditional methods in predicting ovarian response, tailoring IVF stimulation protocols, and improving outcomes (Doe et al. 18). This article explores the advancements in ovarian reserve assessment, focusing on AI's role, challenges, and ethical considerations in clinical applications

Current Methods for Ovarian Reserve Assessment

Traditional ovarian reserve evaluation relies on biochemical and imaging techniques, each with strengths and limitations:

1.Anti-Müllerian Hormone (AMH)

AMH, produced by granulosa cells, is a reliable marker of ovarian reserve due to its stability across the menstrual cycle. High AMH levels correlate with greater ovarian responsiveness during IVF. However, assay variability and reduced sensitivity in populations such as women with polycystic ovary syndrome (PCOS) limit its universality (Garcia et al. 15).

2.Antral Follicle Count (AFC)

AFC, measured via transvaginal ultrasound, counts small follicles (2–10 mm) and is widely used to assess ovarian reserve. While AFC provides a direct measure, its reliability depends on the operator's skill, introducing variability. Advanced imaging technologies, such as three-dimensional and automated systems, aim to improve consistency and precision (Jones 73).

3.Basal FSH and Estradiol (E2)

Basal FSH and estradiol, measured early in the menstrual cycle, have traditionally been used to evaluate ovarian function. Elevated FSH levels often indicate diminished reserve. However, their predictive accuracy is weaker than AMH or AFC, and they exhibit cycle-to-cycle variability (Brown and White 50).

4. Dynamic Testing

Dynamic tests, such as the clomiphene citrate challenge and gonadotropin-releasing hormone (GnRH) agonist stimulation, evaluate ovarian response to hormonal triggers. While effective, these methods are invasive, labor-intensive, and less practical for routine use (Doe et al. 20).

Limitations of Conventional Methods

Despite their utility, these techniques struggle to incorporate complex datasets, predict live birth outcomes, and mitigate inter-observer variability. Emerging technologies like AI aim to address these shortcomings by integrating diverse data sources and offering standardized evaluations (Smith et al. 24).

Transformative Role of AI in Ovarian Reserve Evaluation

Artificial intelligence has introduced innovative solutions for assessing ovarian reserve and predicting IVF outcomes. By leveraging machine learning (ML) and deep learning (DL) models, AI systems can analyze multifaceted data with greater precision and reliability than traditional methods.

1. AI-Enhanced Ultrasound Analysis

AI enhances AFC assessment by automating follicular measurements and minimizing human error. Using computer vision and deep learning, AI-powered ultrasound systems identify follicles and generate three-dimensional imaging, providing more comprehensive evaluations. A 2022 study demonstrated 96% diagnostic accuracy in AI-based ultrasound systems, significantly outperforming traditional approaches (Garcia et al. 19).

2. Integration of Biochemical and Imaging Data

Unlike traditional methods, which analyze data points like AMH and AFC separately, AI integrates these markers with patient demographics to create robust predictive models. This holistic approach improves the accuracy of ovarian response predictions (Patel et al. 105).

3. Personalized IVF Protocols

AI systems analyze extensive datasets from prior IVF cycles to classify patients as poor, normal, or hyper-responders, enabling tailored stimulation protocols. Such personalization minimizes the risks of ovarian hyperstimulation syndrome (OHSS) and enhances treatment efficacy (Doe et al. 22).

4. AI in Embryo Selection

While not directly related to ovarian reserve, AI aids in selecting embryos with high implantation potential through time-lapse imaging and developmental analysis. This integration significantly boosts overall IVF success rates (Brown and White 55).

Real-World Applications and Case Studies

The adoption of AI in reproductive medicine is no longer theoretical, as demonstrated by successful clinical trials and real-world applications.

AI-ASSISTED EVALUATION OF OVARIAN RESERVE AND IVF SUCCESS

1.AI-Assisted Ultrasound for AFC

A multicenter study evaluated the use of AI-enhanced ultrasound imaging for automated AFC measurements across 15 fertility clinics. The AI system achieved a diagnostic accuracy of 96%, reduced inter-observer variability by 70%, and increased clinician confidence in borderline cases (Jones 75).

2.Prediction of Ovarian Response

A study involving 10,000 IVF cycles developed an AI model to predict ovarian response. Patients managed with AI-guided protocols experienced a 15% higher pregnancy rate than those following traditional methods (Doe et al. 24).

3.Comprehensive AI-Driven Assessments

A 2023 European project combined AMH, AFC, and hormonal data in an AI model that predicted live birth outcomes with 88% accuracy, surpassing conventional techniques. Clinicians reported increased patient satisfaction due to the clarity and personalization of AI-generated reports (Garcia et al. 21).

Ethical and Practical Challenges

While AI offers substantial benefits, its integration into reproductive medicine presents challenges:

1.Data Privacy

AI models rely on sensitive patient data, necessitating strict privacy protections and compliance with regulations like GDPR and HIPAA. Data breaches could undermine trust and result in legal repercussions (Smith et al. 28).

2.Bias in AI Models

Training AI systems on non-representative datasets may lead to biased outcomes, disadvantaging certain populations. Developers must prioritize diversity in training data to ensure equity (Patel et al. 108).

3.Transparency and Interpretability

Many AI models function as "black boxes," making their decision-making processes difficult to understand. Explainable AI techniques can enhance transparency and foster clinician trust (Garcia et al. 19).

4.Access and Affordability

High costs and infrastructure requirements may limit AI adoption in resource-constrained settings. Efforts to democratize AI include portable devices and cloud-based platforms (Brown and White 60).

Conclusion

Artificial intelligence has revolutionized ovarian reserve evaluation and IVF optimization, offering unprecedented accuracy, standardization, and personalization. However, its widespread adoption must address challenges such as data privacy, bias, and affordability. Collaborative efforts among clinicians, policymakers, and AI developers will ensure that these innovations are equitable and accessible, paving the way for enhanced reproductive care globally.

AI SOFTWARE SYSTEMS IN OVARIAN STIMULATION PERSONALIZATION

Dr Rashmi Baid Agarwal

Dr Shrutika Thakkar

Introduction:

IVF stimulation protocols play a major role in the outcomes of the cycles and most research papers have hugely emphasized on individualization of these protocols. A successful stimulation depends on anticipation of the ovarian response, which in turn relies on the choice of gonadotropin, dosage, day of trigger, ovarian sensitivity and a plethora of factors that need to be uniquely customized for each patient. Artificial intelligence (AI) with the advantage of machine learning (ML), and deep learning (DL) greatly enhances our ability for personalization of ovarian stimulation protocols, gamete selection, and embryo annotation and selection.

Personalization of ovarian stimulation protocols:

Ovarian stimulation protocols are the key area of focus during IVF treatment cycles and most poor outcomes are attributed to sub-optimal stimulation protocols. An optimal response to the stimulation protocol depends on the starting dose of gonadotrophins administered to stimulate the ovaries and retrieve a sufficient number of mature oocytes that can be fertilized to create viable embryos. Personalization of ovarian stimulation has become increasingly important due to the variability in patient characteristics such as age, ovarian reserve, and hormonal profile. For instance, younger PCOS patients with a higher ovarian reserve may require different stimulation protocols compared to older patients or those with diminished ovarian reserve.

During stimulation, diverse parameters such as patient age, weight, body mass index (BMI), hormonal levels of follicle stimulating hormone (FSH), oestradiol, progesterone and anti-Mullerian hormone (AMH) as well as sonographic parameters such as antral follicle count (AFC), the number and size of growing follicles have to be taken into consideration to take two crucial decisions amongst many others: the starting dose, the trigger. Despite personalized approaches by the treating clinician, predicting individual patient responses to stimulation remains challenging. Suboptimal stimulation can lead to various issues, including ovarian hyperstimulation syndrome (OHSS), poor oocyte quality, and, ultimately, lower IVF success rates.

To eliminate human error and to take advantage of evidence-based algorithms for ovarian stimulation, various software systems have been designed to initiate and guide all therapeutic decisions for ovarian stimulation using the gonadotropins FSH, LH, and hCG trigger.

AI SOFTWARE SYSTEMS IN OVARIAN STIMULATION PERSONALIZATION

Computer applications and ovarian stimulation decisions

Artificial intelligence (AI) can solve the challenge of personalization of ovarian stimulation protocols by taking advantage of vast datasets and leveraging analytical techniques. The core advantage of AI lies particularly in machine learning (ML) and deep learning (DL), that enables us to analyze extensive datasets comprising patient characteristics and historical responses to stimulation protocols thereby improving the accuracy and efficacy of the stimulation protocols. With the help of AI, IVF outcomes that elude traditional analysis by identifying patterns and correlations, may undergo substantial improvements. For instance, AI can identify subtle correlations between specific patient profiles and their responses to different stimulation protocols, enabling more precise treatment tailoring.

Machine learning algorithms can develop predictive models to estimate each patient's optimal type and dose of gonadotropins . These models consider various factors, including age, body mass index (BMI), antral follicle count (AFC), and anti-Müllerian hormone (AMH) levels. AI models even predict the best day for monitoring a patient, trigger day options etc. thereby precisely achieving the desired number of oocytes. Moreso, these software systems have an iterative learning process that integrates data from previous IVF cycles to refine predictions for future treatments.

Key Areas Where AI Enhances Ovarian Stimulation Protocols

- Prediction of Ovarian Response: AI can help predict whether a patient will be a low or high responder to ovarian stimulation, enabling clinicians to tailor the stimulation protocol accordingly.
- Customising Drug Dosages: AI can suggest optimal dosages of gonadotropins (the primary class of drugs used for ovarian stimulation), reducing the risk of both under- and over-stimulation.
- Improving IVF Success Rates: By fine-tuning the stimulation protocols based on individual characteristics, AI can help increase the chances of successful fertilisation and embryo development.
- Reducing Complications: Personalised protocols can also reduce the risks associated with over- or under-stimulation, such as OHSS or poor oocyte quality.

Research studies published on AI in IVF: ovarian stimulation –

Current research in this field has been summarised nicely in a research article by Yen-Chen Wu et al in the Taiwanese Journal of Obstetrics and Gynaecology, January 2025 and tabulated as follows:

- Initial gonadotrophin dose and further dose adjustment: Studies by Gerard Letterieet al (2020), Michael Fanton et al (2022) Nuria Correa et al (2024) have explored the use of AI platforms to successfully optimise FSH dosage resulting in less starting FSH and overall less total FSH used in IVF protocols

AI SOFTWARE SYSTEMS IN OVARIAN STIMULATION PERSONALIZATION

- Protocol selection: AI platforms were studied by Fernanda Murillo et al (2023) and Kaitlyn Wald et al (2021) to randomly assign antagonist, flare protocols to assess if change in protocol yielded different results.
- Sonographic assessment using follicle size and numbers: Xiaowen Liang et al (2022) in their study found that AI enhances follicular monitoring with 3D-US, using 3.0 cm3 for ovulation triggering and 0.5 cm3 for predicting mature oocyte retrieval, outperforming traditional 2D measurements. Another study by Ali Abbara et al from 2018, used AI to determine the follicle size on Day of Trigger most likely to Yield a mature oocyte
- AI and decision-making for best day of trigger: Study by Eduardo Harriton et al (2021) explored a machine learning algorithm can optimize the day of trigger to improve in vitro fertilization outcomes.

Leading AI Software Systems in Ovarian Stimulation Personalization

Several AI-powered software systems are currently being used or researched in the field of ovarian stimulation. These systems employ sophisticated machine learning algorithms to analyze clinical data and provide personalized recommendations for ovarian stimulation protocols. Lot of research is ongoing in this area. Notable among the same is a study by Chelsea Canon et al, 2024 which is amongst the first clinical trial to prospectively evaluate the efficacy of AI for optimizing the starting dose of FSH and timing of trigger injection. The Evaluation of the Stim Assist Clinical Decision Support Software—An Observational Post-Market Study (LILY) was designed to collect data on patients undergoing IVF treatment where Stim Assist was utilized by clinicians during stimulation. The primary study endpoint was to compare the mean number of mature oocytes (MII) retrieved for patients undergoing IVF treatment with Stim Assist compared to matched controls from historical patients treated by the same doctor during the year prior. Stim Assist is a clinical decision support software intended for use prior to the start of an ovarian stimulation cycle to help optimize the starting dose of FSH and throughout the stimulation cycle to help optimize the timing of the trigger injection. Stim Assist includes two previously published AI algorithms: a Starting Dose Tool that creates a a dose–response curve relating the predicted number of MII for different starting doses of FSH and a Trigger Tool that uses a patient’s E2 and follicles to predict the number of mature eggs if triggering today, tomorrow, or in two days.

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Figure 1- Starting Dose Tool: In this example, the tool predicts that a patient would retrieve the maximum number of MII (14.4 ± 1) at a starting FSH dose of 300 IU.

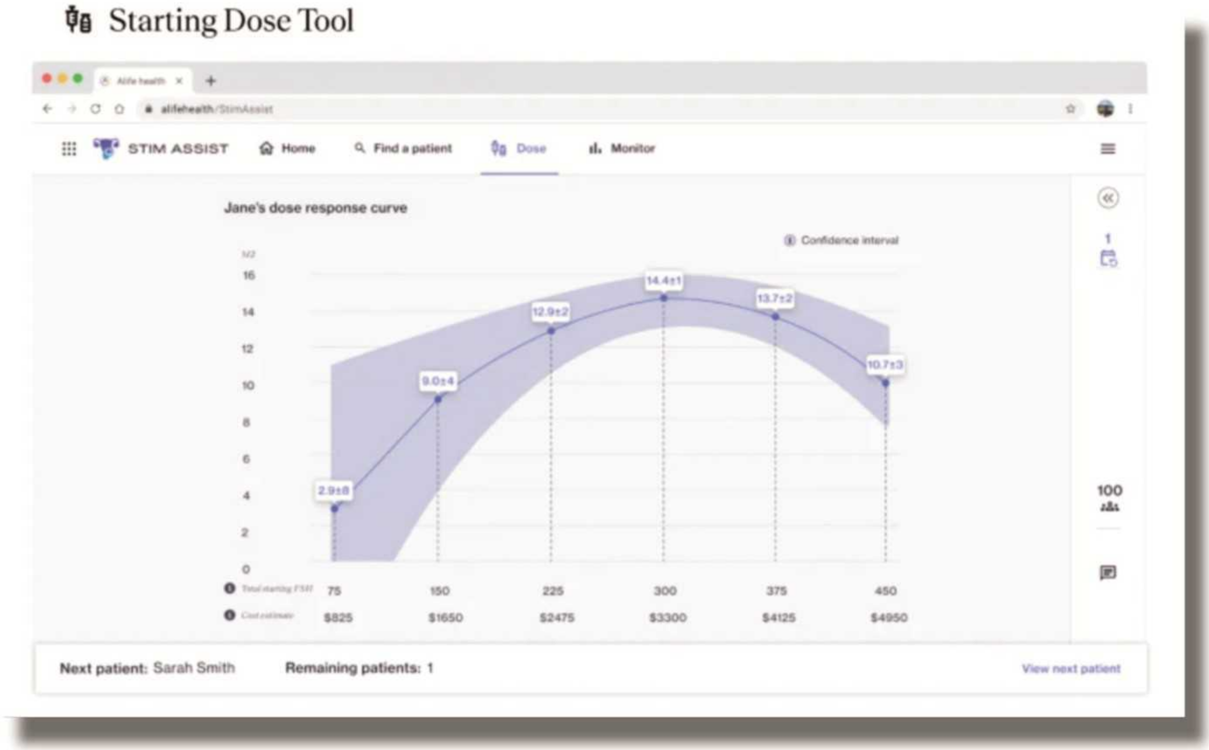
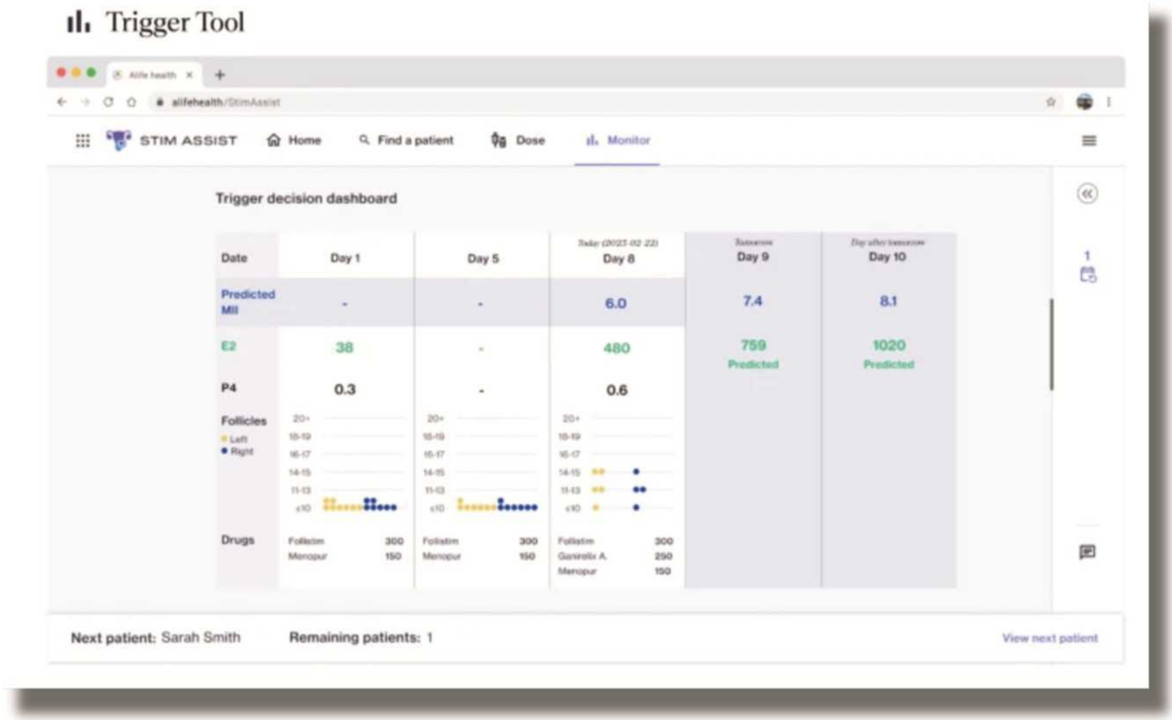


Figure 2: Trigger Tool - In this example, the Trigger Tool predicts 6.0 MII if triggering today, 7.4 MII if triggering tomorrow, and 8.1 MII if triggering in two days, suggesting that the patient should continue to be stimulated in order to increase egg yield.



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Another AI platform available for use and studied by Emperaire JC et al is StimXpert. StimXpert is a software system designed to initiate and guide all therapeutic decisions for ovarian stimulation using the gonadotropins FSH, LH, and hCG. Because evidence-based algorithms for ovarian stimulation have not existed, this experience-based application was developed to fill the need. The present configuration includes 10 specific protocols: four for mono-follicular anovulatory stimulation (step-up low dose, step-up chronic low dose, step-down and sequential), two for ovulatory patients preparing for intrauterine insemination (mono- or bi-follicular), and four utilized for controlled hyperstimulation (long agonist, short agonist, fixed antagonist, flexible antagonist). For each protocol, the starting dose is dictated by the patient's weight and her level of plasma AMH. The StimXpert software aims to facilitate the acquisition of technical principles of ovarian stimulation and to optimize the chances of pregnancy together with diminishing risks for complications such as multiple pregnancies and OHSS.

Impact of AI on IVF Success Rates

The use of AI in personalizing ovarian stimulation protocols has been shown to significantly improve IVF outcomes. One of the primary benefits of AI-based systems is their ability to reduce variability in ovarian response, which is crucial for improving fertilization and implantation rates. Personalization ensures that the stimulation protocol is better suited to each patient's unique biology, leading to more predictable results.

Several studies have demonstrated that AI-guided protocols can improve both the quantity and quality of oocytes retrieved, as well as the likelihood of a successful pregnancy. Research published by Liu et al., 2022 reported that AI-driven models were able to predict ovarian response and optimize gonadotropin dosages, leading to a reduction in the rates of OHSS and a higher likelihood of achieving a healthy pregnancy. A regression model called PMORN is proposed that can accurately predict the number of oocytes retrieved. The proposed models could serve as a scientific tool to predict the ovarian response and enable a customized, individual treatment of the COS for subsequent IVF cycles.

Thus by incorporating historical patient data, AI can enhance the personalization of stimulation protocols, resulting in improved clinical outcomes. Moreover, AI can also facilitate real-time adjustments to stimulation protocols. By monitoring patients' responses during the stimulation phase, AI algorithms can recommend modifications to the dosage or type of gonadotropins. This dynamic approach ensures that the protocols are constantly optimized to achieve the best possible outcomes, reducing the incidence of complications like OHSS and enhancing overall treatment efficacy

Conclusion: The integration of AI into ovarian stimulation represents a transformative shift in ART. AI has the potential to enhance quality control and workflow optimization within IVF laboratories by continuously monitoring key performance indicators (KPIs) and facilitating efficient resource utilization. However AI is currently in a very nascent stage and its role in improving clinical outcomes remains to be confirmed by large-scale, well-designed clinical trials. Additionally, Ethical considerations, including data privacy, algorithmic bias, and fairness, are paramount for the responsible implementation of AI in IVF. Future research should prioritize validating AI tools in diverse clinical settings, ensuring their applicability and reliability. Collaboration among AI experts, clinicians, and embryologists is essential to drive innovation and improve outcomes in assisted reproduction.

WORD SEARCH

PUZZLE

ARTIFICIAL INTELLIGENCE IN ASSISTED REPRODUCTION

Instructions: Find the following words in the grid. Words can appear horizontally, vertically, or diagonally

A	I	L	R	T	U	L	S	D	M
C	V	F	I	A	E	O	A	O	O
D	A	T	A	M	L	O	D	A	E
U	L	T	R	A	S	O	U	N	D
T	E	H	I	C	S	U	T	M	L
O	M	B	R	Y	O	T	O	E	E

WORDS TO FIND:

1. AI
2. IVF
3. DATA
4. EMBRYO
5. LAB
6. MODEL
7. ETHICS
8. ROBOT
9. AUTOMATE
10. ULTRASOUND
11. SPERM
12. SORTING
13. SELECTION

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