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Obstetrics & Gynecology

VOLUME 14

Dasgupta's Recent Advances in Obstetrics and Gynecology

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CHAPTER 18

Artificial Intelligence in Reproductive Medicine

Rohan Palshetkar, Nandita Palshetkar

INTRODUCTION

Artificial intelligence (AI) is the personification of man-machine partnership. In the present wave of digitalization, the utilization of digital technology in reproductive medicine is not surprising. John McCarthy first used this term in 1955.[1] Artificial intelligence, at its core, is enabling computers to mimic cognitive functions of human mind including learning, analyzing, and problem-solving. Machine with AI lacks human emotions and consciousness. With the increasing use of AI in reproductive medicine, its accuracy is increasing resulting in standardization and greater precision. It helps fertility specialists to individualize patient management in ways much superior to what might be possible by humans alone.

Artificial intelligence has wide applications ranging from automated reasoning (machines completely reasoning automatically) and knowledge representation (diagnosing a medical condition using computers) to automatic planning (automatic cars or autonomous robots). Machine perception is also an important application, wherein computers are capable of interpreting data in fashion similar to humans using their natural senses such as touch, smell, vision, and hearing.

Artificial intelligence allows simultaneous assessment of complex variables critical for human reproduction, both clinical and scientific. It is increasingly being used in our field for analyzing patient characteristics such as age, demographics, and prediction of ovarian reserve as well as in the in vitro fertilization (IVF) and embryology laboratory.

MACHINE LEARNING

Machine learning (ML) is a subgroup of AI, where a machine is meant to learn and adapt to circumstances undergoing self-driven data training **(Fig. 1)**. ML encompasses training a computer program using complex training data sets which uses feeding images describing different features such as shape, color, and texture to make predictions. For example, ML empowers the machine to differentiate between cancerous and noncancerous lesions by taking picture with the camera and using image analysis.

Machine learning focuses on forming automated clinical decision systems to assist practitioners in predicting pregnancy outcomes and planning treatment. ML typically requires reliable databases, providing enormous data

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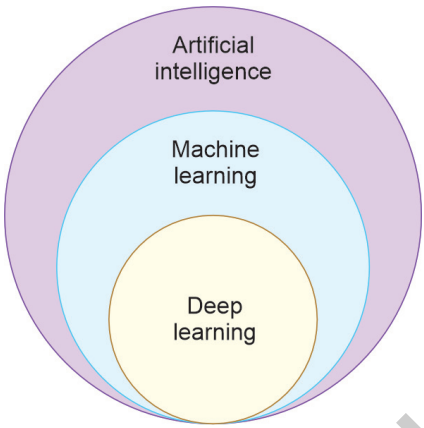

Fig. 1: Machine learning—a subgroup of artificial intelligence.

input for better predictions. In the present era of high-quality data, ML can become an indispensable clinical tool.

Supervised, unsupervised, and reinforcement learning are different approaches of ML.[2] Supervised learning is the most common ML used in reproductive medicine for image analysis and prediction of assisted reproductive technology (ART). This algorithm utilizes labeled data for developing prediction models of a known output. In unsupervised learning, hierarchal clustering is used to determine structure within classes and can be used to predict unknown results. The machines have high energy consumption as they operate at high speed and need a great amount of memory backup, which is possible with cloud computing. Reinforcement learning aims on improvement of the accuracy of algorithms through trial and error.

NEURAL NETWORKS

Artificial neural networks (ANNs) are the most common algorithms for image analysis. It mimics the way human brain works. The neural network is in digital space. Each neuron receives signals from multiple neurons, integrates them, and then fires them in all directions. ML analyzes images using this deep neural network. The computer keeps on refining itself every time, so that next time it analyzes in a faster and better way.[3] The main aim of neural networks is to learn to arrive at an accurate prediction. Neural networks are mainly used in reproductive medicine to predict IVF outcome. For example, Milewski et al. in 2009 created an ANN model for the prediction of adverse pregnancy outcome in IVF cycle. They concluded an excellent result to predict treatment failure with around a 90% probability rate.[4]

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APPLICATIONS OF AI IN REPRODUCTIVE MEDICINE

Sperm Selection and Semen Analysis

Artificial intelligence can help predict male factor infertility to study the effect of lifestyle and environmental factors on the quality of semen and fertility rates. The computer-assisted semen analysis (CASA) is no more experimental and is increasingly being used in clinical practice in order to decrease human error and the ease of analyzing higher number of samples in less time. The novel smartphone-based applications can be used for the assessment of sperm viability as well as DNA integrity. Currently, research is ongoing, for selection of best sperm for intracytoplasmic sperm injection (ICSI). A new system is being proposed, which connects the ICSI screen to the Internet, in real time, and then to the AI server, thus guiding the embryologist in identifying the best sperm to immobilize and inject into the oocyte. This application of AI is promising to improve fertilization rates, high-quality embryos, and thus better IVF outcome.

Embryo Grading and Selection

The introduction of automated morphological ranking system for grading embryos is quite beneficial in selecting best embryo prior to transfer. Additionally, the recent use of time-lapse monitoring system in modern IVF centers provides continuous images of the developing embryo and its morphology. Carrasco et al. in 2017 analyzed 800 human embryos with known implantation potential retrospectively with a time-lapse system incubator. They developed a model based on the morphological assessment of D3 embryos, which was helpful in predicting embryos with the least implantation potential.[5] AI can also be used to predict the implantation potential and genetic euploid status of the blastocyst for single embryo transfer. In the future, we will be able to correlate the genetic competence of the embryo with actual visual analysis, and the machine will slowly learn, identify, and guide the embryologist, in selecting the best embryo for transfer.[6] This will obviate the need to perform complex tests such as next-generation sequencing on DNA obtained from the embryo.

Oocyte Evaluation and Selection

The success of ART is largely dependent on oocyte quality. AI has been recently used for the assessment and grading of mature oocytes prior to fertilization or cryopreservation. The AI system exports the images of the oocytes, to the server, which in turn, predicts whether the eggs will yield a good blastocyst and pregnancy, when thawed and fertilized, in the future. The data can also be used to counsel patients undergoing elective egg freezing for fertility preservation. It can help the patient in deciding whether there is an adequate number of good quality eggs, to assure her of a future pregnancy. In case, the

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good quality eggs are less in number, the patient can decide to undergo an additional cycle of oocyte retrieval and cryopreservation, thus improving her chances of a successful pregnancy, in the future.

Prediction of In Vitro Fertilization Outcome

Fertility specialists can individualize the treatment of subfertile couples and predict ART outcomes using AI-based IVF prediction models. Although the accuracies of different such models have increased to around 85%,[7] further research is needed to apply it in clinical practice.

Embryo Transfer

Artificial intelligence can also guide in performing a perfect embryo transfer, thus improving pregnancy outcome. It can analyze the endometrial lining, thickness, appearance, and the endometrial blood flow. The machine can correlate these images and help us to decide whether the endometrial lining is ideal for transfer or not. If the lining is not appropriate, one can plan a transfer in the next cycle.[8]

Other Uses

Artificial intelligence is also used in administration, medical records keeping, laboratory, and research. Recently, some IVF specialists in USA are utilizing AI to distribute the work in the clinics, so that everyday there is the same number of patients for ovum pick-up. AI can be used for stock-taking, inventory, and quality control, thus improving work efficiency in the embryology laboratories.

DISADVANTAGES AND LIMITATIONS OF AI

- There is a lack of standardization of AI as multiple platforms are being used. The machine should have a balance of good and bad images to guide us correctly. Some laboratories are developing programs, which can eliminate bad data, thus improving results which can be misleading.
- Moreover, the machine must have data based on ethnic diversity, for example, Indian people are different from Caucasian people, hence data from diverse groups is needed. Analysis and interpretation of data in different countries might lead to wrong results. The pooling of information has to be done from multiple data sets, to help us make better predictions. The data sharing implementation and integration of information are important.
- Selection bias from sample collection can lead to poor performance of AI models.
- People are scared that AI may create a lot of job losses with a prediction of 9–47% job loss. The fields involving human-to-human contact will remain in the future, but the fields currently using a lot of automation will be taken over by machines. As the machines are trained, there is a fear that AI will

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spell the end of the human race. Stephen Hawking said that "once Man develops artificial intelligence, AI will take off on its own and redesign itself at an ever-increasing rate. Humans, limited by slow biological evolution, will be unable to compete and will be superseded by Machines." However, the opinions of experts within the field of AI are mixed, both concerned and unconcerned by this eventual superhuman capacity. The danger of uncontrolled advance needs to be realized. However, AI will unfold a huge number of possibilities, such as curing disease and better ART outcome.

CONCLUSION

Artificial intelligence is the wave of future which will bring a new era in reproductive medicine. AI will serve practitioners by improving diagnosis and treatment efficiency. The standardization, automation, and precision of IVF driven by AI will provide great benefits to infertile patients and society. Further research is needed in this field by large IVF groups to accumulate the wealth of data needed to achieve sufficient sample size. This will provide broader application of AI with better prediction models.[9] Moreover, AI will not replace fertility specialists and embryologists, rather it will streamline their efforts with better pregnancy outcome.

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