Research Article

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Journal of Womens Health and Reproductive Medicine

2020
Vol. 4 Iss. 1

Artificial intelligence in reproductive medicine

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Citation: Gupta S, et., al

Received: June 06, 2020;
Accepted: June 13, 2020;
Published: June 20, 2020

Introduction

At its core, artificial intelligence (AI) is "a partnership between man and machine" (Ginni Rometty, IBM CEO). The embodiment of AI is a computer program that can learn to execute tasks involving forms of intelligence normally ascribed to humans. How well a computer will be able to emulate or exceed humans is the essential question driving AI technology. (1) The term AI was first coined by John McCarthy at the Dartmouth Summer Research Project on Artificial Intelligence in 1955.

The potential introduction of AI into the clinical ART world holds both tremendous benefits and ethical complexities. If approved for clinical application, the use of AI to separate high- quality embryos from those that are chromosomally abnormal might save healthcare professionals time and effort by processing and interpreting more data with greater depth and precision. This might, in turn, improve the efficiency of ART and subsequent pregnancy outcomes, treatment options and care for patients with infertility. At a societal level, it could minimise healthcare costs by reducing the use of unnecessary testing or treatment. (2)

While AI is currently being tested in several areas of reproductive medicine—including sperm identification and morphology, automation of follicle counts, automatic embryo cell stage prediction, embryo evaluation, and prediction of live birth, as well as developing improved stimulation protocols (3)

AI assessment of embryo images or videos raises additional possibilities and perhaps great potential. Could the analysis of a powerful computer detect patterns of embryo morphology associated with viability that are elusive to the human eye? For example, pioneering work by Rocha et al. (4)

The ability to precisely diagnose disease and apply individualized treatment has been shown to improve clinical outcome (5) Majority of success of an IVF cycle depends on the role of an embryologist. There have been no enhancements in technology for these trained technicians in the past decade which may assist them in standardizing the process. Therefore, there is a huge variability that can be seen in different labs. An ideal way to solve this problem would be to completely automate this process and reduce the manual variability that is seen today.

That would completely change the game in the IVF industry and make IVF a consistently successful procedure.

In some patients, a low sperm count or poor sperm quality prevents successful conventional IVF, and then ICSI is preferred.

Conventionally, sperm immobilization is performed manually, which entails a long period of training to achieve the required skills. Leung

et al. (6) presented a system for fully automated sperm immobilization to eliminate limitations in manual operation.

To create a system for automated sperm immobilization, sperm head and tail tracking algorithms are essential for visually tracking the spatial location of the sperm, for controlling

the microscope to move the sperm to the centre of the field of view, and for averaging the tracked head and tail positions to locate the midpoint of the sperm tail for robotic immobilization. Before the invention of this device, computer-assisted sperm analysis has been used to develop algorithms for tracking sperm trajectories measuring sperm velocity, but the low contrast of the sperm tail under optical microscopy is a major reason why sperm tail tracking is challenging. Other reasons are that the motion of a sperm tail is sporadic and multimodal, i.e., sperm undergo temporal dynamic changes. In brief, the automatic system should be capable of immobilizing sperm with visual tracking integrated into the system for following sperm position, locating the sperm tail midpoint, and controlling multiple motion control devices for sperm immobilization. The system proposed by Leung et al. demonstrated a sperm tail visual tracking success rate of 96%, a sperm immobilization success rate of 88.2%, and a speed of 6–7 seconds per successful immobilization.

Once sperm is immobilized, the next step is microinjection or ICSI. A piezo actuator technology for ICSI of human oocytes was initially described by Huang et al. (7). Defining what the best sperm, oocyte, or embryo is remains a challenge, until controlled trials demonstrate the usefulness of new techniques. (8)

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