Measurement of uterine contractions could predict the outcome of in vitro fertilization

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In vitro fertilization (IVF) is considered as the gold standard of assisted reproductive technologies. Yet, the failure rate for IVF treatments is still above 70 percent, and the exact causes of failure remain unknown.

Federica Sammali, Ph.D. candidate at the department of Electrical Engineering, has developed a system for measuring and characterizing uterine contractions, which are known to influence the outcome of IVF. Via mathematical models and machine-learning approaches, Sammali was able to discriminate between favorable or adverse uterine activity in non-pregnant women and predict the outcome of IVF with an accuracy of 94 percent. Her results could be used in the future for effective decision making, to ultimately improve the success rate of IVF. Sammali defends her Ph.D. project on November 4th.

Worldwide, the rate of couples dealing with infertility is over 20 percent. For most infertile couples, the only hope lies on assisted reproductive technologies such as in-vitro fertilization (IVF). Worldwide, nearly 2.4 million IVF cycles are performed every year, but only 500,000 babies are born. In the Netherlands alone, over 12,000 IVF cycles fail every year, with associated costs of about 60 million euros. To date, the exact causes of failure remain unknown, and women have often to undergo repeated unsuccessful attempts with considerable emotional consequences.

Uterine contractions

Uterine contractions are known to influence the outcome of IVF. Precise interventions on contractions are possible and can boost the success rate of IVF. Unfortunately, these are hampered by a lack of techniques for measuring and characterizing contractions in a non-pregnant uterus. To date the only options for quantification of uterine contractions have been either invasive, such as intrauterine pressure catheters, or indirect and harmful for the women, as they require ionizing radiations.

Electrical and mechanical activity

Federica Sammali, Ph.D. candidate in the Signal Processing group led by prof. Jan Bergmans, introduced new, non-invasive solutions to monitor the uterine contractions and predict the outcome of IVF. In a clinical study performed at the Catharina Hospital of Eindhoven under the supervision of prof. Dick Schoot, Sammali measured the electrical activity of the human uterus outside pregnancy by positioning an electrode grid on the abdominal surface of non-pregnant women (Figure 1). The electrical signals collected by Sammali showed differences in amplitude and frequency content between the different phases of the natural menstrual cycle, evidencing value for assessment of the uterine condition.

Next to the electrical activity, ultrasound technology was used to quantify the mechanical activity of the uterus in terms of motion and strain. Sammali successfully extracted tiny movements of the uterus from the larger movements generated by surrounding organs. This was achieved throughout a novel setup generating controlled movement of an ex-vivo human uterus (Figure 2). A following clinical study at the Catharina Hospital in Eindhoven confirmed the ability of the method to discriminate between the different phases of the natural menstrual cycle in healthy women.

Improved decision-making

Based on these promising results, Sammali performed a clinical study at Ghent University Hospital, under the guidance of prof. Dick Schoot and prof. Frank Vandekerckhove. Women undergoing an IVF cycle were monitored and the ability to predict the success of IVF was investigated. The predictive model developed by Sammali was able to discriminate favorable or adverse uterine activity with up to 94 percent accuracy.

Massimo Mischi, full professor in the Signal Processing Systems group and principal investigator of the project, says, "Although a wide clinical

uptake requires further validation, this result already evidences the potential of the proposed method for efficient decision making." Based on the monitoring systems developed by Sammali, doctors might indeed either proceed with the embryo transfer when successful IVF is predicted, or choose for different strategies when failure is predicted. Alternative strategies may then consist of waiting for more favorable uterine activity or modulating the uterine activity by pharmaceutical compounds. "A small improvement by 10 percent," says Mischi, "would already lead to yearly saving of €6 million in the Netherlands alone."

The impact of the research of Sammali goes even beyond IVF. Mischi: "This method has been tested in uteri presenting fibroids (myomas) or thickening of the endometrium (adenomyosis), showing promise also for the diagnosis of these common uterine dysfunctions."

Federica Sammali defends her Ph.D. thesis on November 4th 2019 at TU/e. The title of her Ph.D. thesis is "Measurement of the electromechanical uterine activity in the non-pregnant human uterus."

More information: Measurement of the electromechanical uterine activity in the non-pregnant human uterus. pure.tue.nl/ws/files/138191977 … 20191104_Sammali.pdf

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