A non-invasive Artificial Intelligence (AI) algorithm can predict competence of denuded oocytes from images taken prior to intracytoplasmic sperm injection (ICSI)

Summary: A novel AI algorithm had high predictive power for assessing whether oocytes will develop into a usable blastocyst from single, static oocyte images, denuded prior to ICSI. Further, a UDC data cleansing technique was able to improve AI performance by identifying and removing cases where good quality oocytes were likely mislabeled as non-competent due to external factors beyond oocyte quality, such as male infertility.

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Objective

To investigate whether a non-invasive, deep learning AI algorithm trained on static images of oocytes, denuded prior to ICSI, can predict whether oocytes will develop into a blastocyst.

Materials & Methods

This study involved a prospectively collected dataset of 1180 static oocyte images, denuded and imaged immediately prior to ICSI, from 116 consecutive patients treated at a single US clinic in 2021. Each image contained a single oocyte, with a linked blastocyst development outcome.

AI models were developed, both pre- and post-removal of male infertility cases, using oocyte images labeled with usable blastocyst outcome. Training utilized the UDC [1] data cleansing method, with performance evaluated using binary metrics: overall accuracy, sensitivity and specificity. Predictive power was assessed on an uncleansed validation set of 236 images (prior to application of UDC). Final predictive power with male infertility cases removed was assessed on a cleansed validation set of 92 images.

[1] Milad A. Dakka, *et al.* "Automated detection of poor-quality data: case studies in healthcare", Nature Scientific Reports, 2021; 11(1): 18005.

Results

The UDC data cleansing method was applied to the 1180 oocyte images used for AI development. A mean accuracy of 61.8% for constituent AI models was reported on the uncleansed validation set, which increased to 63.2% on removal of known male infertility cases. Interestingly, **31.6%** of known male infertility cases were correctly identified and removed by the UDC method, suggesting it is a major source of mislabeling.

To control for the impact of male infertility on blastocyst development, all images with known male infertility factors were removed prior to applying a second round of data cleansing, removing data that may include additional external sources of mislabeling (e.g. laboratory error). A mean accuracy of 66.9% was reported for AI models trained on this cleansed dataset, which is a relative improvement of **8.3%** compared with AI models trained on the uncleansed dataset.

A final ensemble model consisting of two constituent AI models trained on the whole oocyte image, and one model trained only on the segmented zona pellucida region, demonstrated a high overall accuracy of **83.7%** for predicting blastocyst formation on the cleansed validation set (sensitivity **78.8%**, specificity **86.4%**.)

Wider Impact: There is currently no widely adopted methodology for determining oocyte competency. Such a development could decrease time, cost and unnecessary stress for patients, allowing informed choices regarding oocyte selection or the necessity of further IVF cycles.

31.6% Known male infertility cases identified using UDC, which were likely mislabeled as non-competent oocytes.

8.3% AI accuracy improvement by training the AI on a UDC cleansed dataset excluding the mislabeled oocyte data.

83.7% Final AI model accuracy on the cleansed validation set of 92 images with known male infertility cases removed.

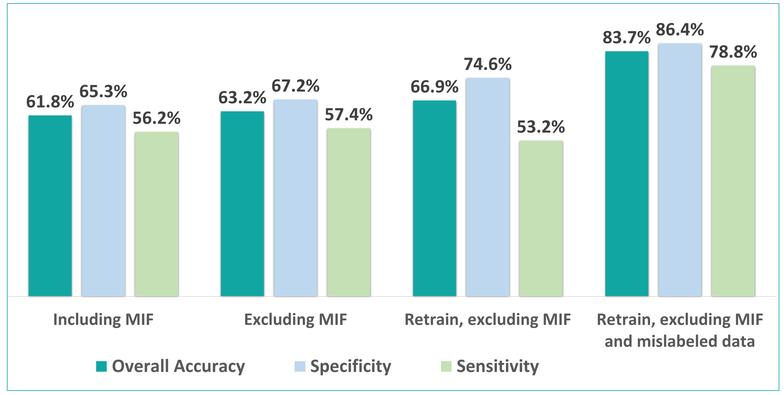

Figure 1: Mean accuracy metrics for AI models for 4 scenarios: (1) including male infertility factors (MIF), (2) excluding MIF, (3) retraining the model with MIF excluded and (4) retraining the model with both MIF and UDC-identified mislabeled data excluded.