ORAL COMMUNICATIONS

PREIMPLANTATION EMBRYO MORPHOLOGICAL FEATURES AS NON-INVASIVE MARKERS OF DEVELOPMENT TO BLASTOCYST

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Preimplantation embryo development involves tightly regulated morphological transitions whose details remain poorly understood. The overarching goal of this study is to exploit the potential of morphological features such as the zona pellucida, cytoplasm and pronuclei, and their morphometrical measurements as markers of developmental competence to the blastocyst stage. We used a dataset of time-lapse images of human embryos, obtained during routine in vitro fertilization clinical settings. Specifically, we manually segmented the zona pellucida, cytoplasm and pronuclei in time-lapse images of 100 human embryos across the first 30 hours of development, from fertilization (ICSI) to the 2-cell stage. The resulting segmentation masks served as ground truth to train a deep learning automatic segmentation model (Mask R-CNN). Model performance was evaluated using the Dice coefficient, achieving a cumulative Dice of 0.83, with strong results for cytoplasm (0.97) and zona pellucida (0.89), and lower performance for pronuclei (0.63), reflecting the inherent challenges of detecting small, dynamic and low-contrast structures. Future directions include increasing the training set of embryos and extracting morphometric measurements (e.g., ZP thickness, diameter and area) from the predicted masks. This will allow us to link these measurements to the embryo fate, providing a quantitative framework to guide future research into the biological processes underlying preimplantation development and paving the way for the creation of an embryo development predictive tool.

Acknowledgments: This work was funded by the ESHRE Research Grant 2024.