ESHRE 42nd Annual Meeting 2026

Poster Number: L26/P-135

Noninvasive micro-MRS metabolic fingerprints predict *in vitro* blastocyst progression up to hatching in mammalian embryos

Marco Grisi[1*], Serena Lucia Bitetti[1], Arthur Barakat[1], Kathryn B. Marable[1], Claudia Cordara[1], Chloe Gioiosa[1], Luciano Alberto Maria[2], Lodde Valentina[2], Fernanda Fagali Franchi[2], Francisco Marco-Jiménez[3], Giulia Sivelli[1*]

[1]Annaida Technologies SA, Lausanne, Switzerland; [2] Reproductive and Developmental Biology Laboratory (ReDBioLab), University of Milan, Italy; [3]Universitat Politecnica De Valencia.

*marco.grisi@annaida.ch *giulia.sivelli@annaida.ch

www.annaida.ch

Study Question

Can noninvasive micro–magnetic resonance spectroscopy (micro-MRS)–derived metabolic fingerprints predict in vitro blastocyst developmental progression beyond conventional morphological assessment?

Study Answer

Micro-MRS metabolic profiles predict in vitro blastocyst progression up to hatching with ≥70% accuracy in bovine and rabbit embryos and retain predictive value beyond standard morphology.

Background

Current IVF embryo selection relies on morphology and *morphokinetics*, offering limited physiological insight and modest predictive value for implantation. Micro-MRS addresses this gap by enabling noninvasive, single-embryo metabolic profiling, quantifying lipid and water resonances to assess developmental competence and predict blastulation.

Methods

Prospective experimental study acquiring ^{1}H micro-MRS spectra from Day 6/7 bovine (N=120) and Day 3 rabbit embryos (N=285), followed by 24–48 h *in vitro* culture to track developmental progression. *In vitro*-produced embryos were analyzed in a 7T spectrometer using Annaida's micro-MRS probe (Figure 1). Spectral features, lipid and water resonances, were quantified per embryo. XGBoost and SVM classifiers were trained to predict full expansion or hatching. Morphological variance was regressed out to isolate spectral information independent of visual grading.

Study funded by Annaida Technologies SA. No competing interests to declare.

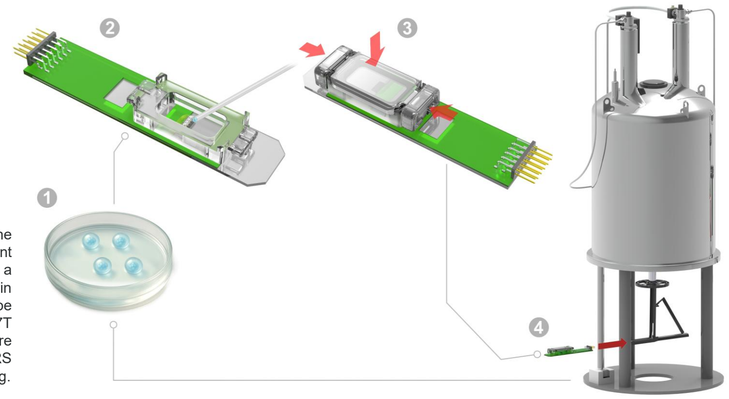

Figure 1. Schematic of the micro-MRS measurement workflow. Four embryos at a time are positioned within Annaida's micro-MRS probe (1-2) and analyzed in a 7T spectrometer (3–4) to acquire single-embryo ^{1}H MRS spectra for metabolic profiling.

Results

Bovine Embryos

Increased lipid content in bovine embryos was associated with delayed or absent progression to full expansion or hatching (Figure 2). XGBoost and SVM classifiers distinguished embryos with blastocyst-stage progression from non-progressors (balanced accuracy 0.72; AUC 0.84). After removing spectral variance attributable to conventional morphology, predictive performance was largely preserved (balanced accuracy 0.69; AUC 0.79), indicating that micro-MRS metabolic fingerprints capture information beyond standard morphological assessment.

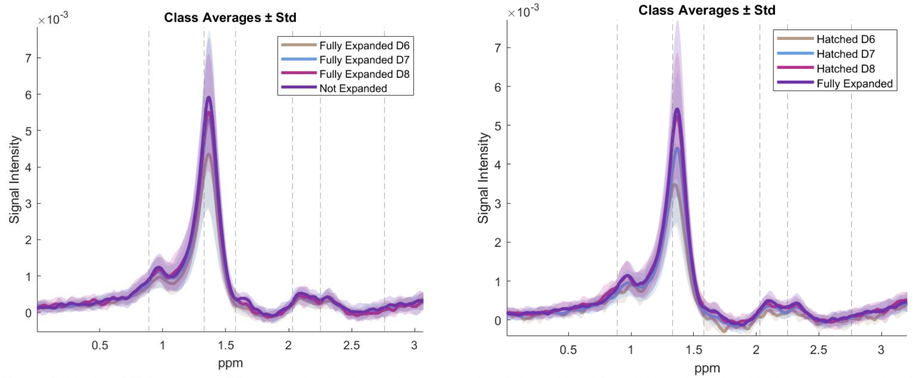

Figure 2.^{1}H micro-MRS spectra (±SD) comparing bovine embryo expansion (left) and hatching (right) trajectories. Lipid resonance peaks (0.5–3 ppm) differ systematically between fully expanded, hatched, and non-progressing embryos, reflecting metabolic differences underlying developmental competence.

Results

Rabbit Embryos

In rabbit embryos, comparable classification performance was achieved despite lower signal intensity (balanced accuracy 0.70; AUC 0.75) (Figure 3). Conserved lipid resonances and water peak–related features contributed consistently to prediction across both species, supporting cross-species translatability. Classifier performance exceeded chance in all permutation tests and confidence interval analyses, confirming model robustness.

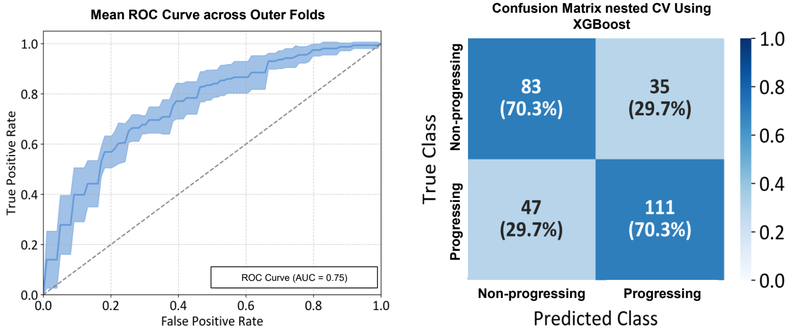

Figure 3. Classifier performance in nested cross-validation. (Left) Mean ROC curve across outer folds (AUC = 0.75), demonstrating above-chance discrimination between progressing and non-progressing rabbit embryos. (Right) XGBoost confusion matrix showing 70.3% balanced accuracy, with 83 true non-progressing and 111 true progressing embryos correctly classified.

Study Limitations

Species-specific differences in embryo metabolism and lower signal intensity in rabbit embryos indicate potential variability in sensitivity. Clinical validation in human embryos, correlating with implantation, clinical pregnancy, and live birth outcomes, is required.

Wider Implications of the Findings

Micro-MRS–derived metabolic fingerprints may overcome conventional morphology limitations by providing noninvasive functional biomarkers of embryo viability that generalize across mammalian species, with potential to improve embryo selection strategies and clinical outcomes in human and animal assisted reproductive technologies.

Authors affiliated with Annaida Technologies disclose a conflict of interest, as the company is developing the Micro-MRS device presented in this poster. All other authors declare no conflicts of interest.