GALACTIC COSMIC RADIATION AND OVARIAN IMPACT -- AN ARTIFICIAL INTELLIGENCE-ASSISTED ANALYSIS

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Introduction

As space exploration advances and missions become longer, it is critical to understand the extended effects of galactic cosmic radiation (GCR) on ovarian function. Ovarian follicle counts and serum anti-Müllerian hormone (AMH) levels serve as markers of fertility potential. Literature has shown that high-dose-rate GCR results in reduced follicle pools and lower AMH levels. However, the effect of a chronic low-dose-rate GCR analog on these outcomes is unknown in longer duration missions. In addition, current methods for quantifying follicles in histologic sections are labor-intensive and prone to inter-rater reliability error. Deep learning models have demonstrated potential to automate antral follicle counting, yet this has not been validated for primordial, primary, or secondary follicles (1).

Objectives

This study sought to determine the effects of a simulated 50-day space mission on ovarian reserve in a mouse model, and to quantify murine ovarian follicle counts after GCR-analog exposure using a novel AI-assisted image analysis model.
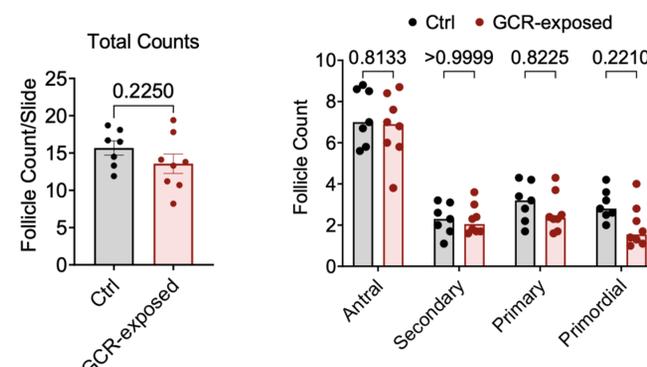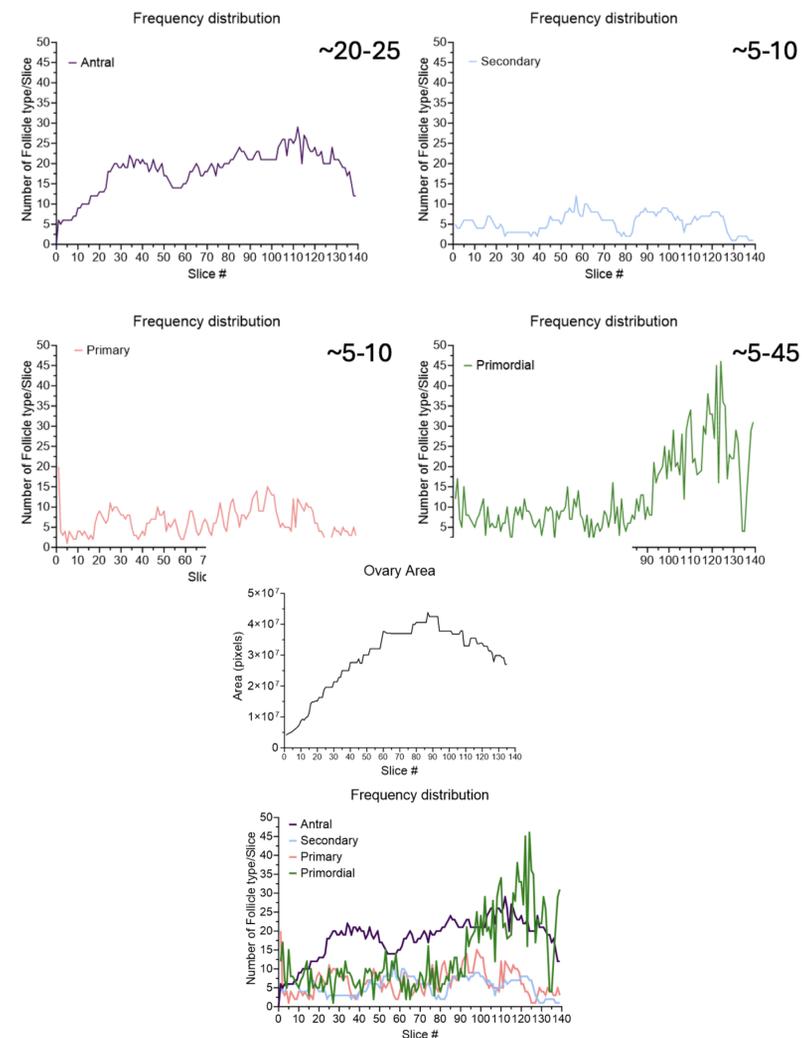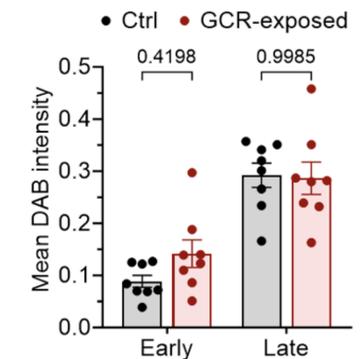
Methods

Figure 1: Methods
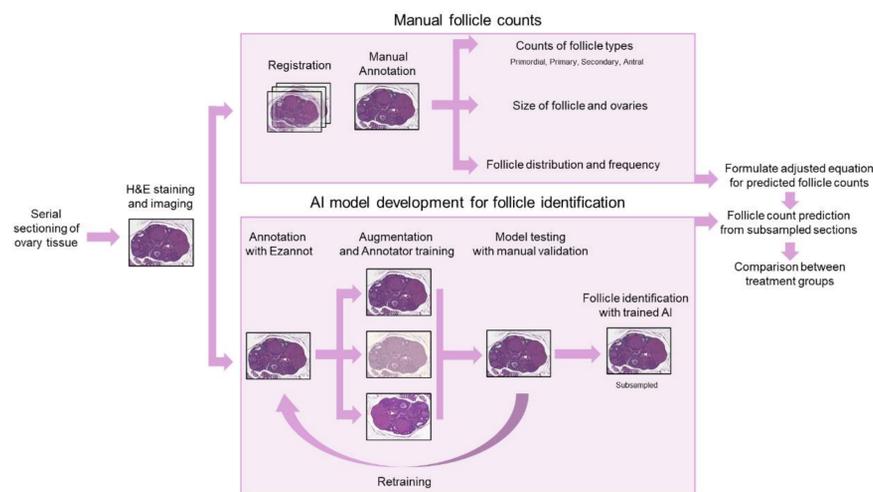
Results

Figure 2: Follicle Distribution and Frequency

Results

Table 2: AMH Stains in Early and Late Follicles

Cf-exposed ovaries demonstrated a significant reduction in primordial follicle counts compared to controls (p=0.044). Primary (p=0.315), secondary (p=0.952), antral (p=0.506), and total follicle counts (p=0.225) were not significantly different. IHC staining and scoring for AMH demonstrated no significant difference between Cf-exposed vs. control mice, albeit early follicle DAB mean intensity trended higher (p=0.089) in Cf-exposed mice.

Conclusion

AI-assisted histologic analysis demonstrated a trend towards lower follicular counts after 50 days of exposure in a GCR analog. Ovarian AMH staining showed no significant differences, suggesting other mechanisms contribute to reduced primordial follicle pools. This pilot study offers an important methodological foundation to build off for future space radiation ovarian function studies.

References

1. Hassan, et al. Automatic ovarian follicle detection using object detection models. *Sci Rep* 14, 31856 (2024).
2. Mishra B, Ortiz L, Luderer U. Charged iron particles, components of space radiation, destroy ovarian follicles. Hum Reprod. 2016 Aug;31(8):1816-26. doi: 10.1093/humrep/dew126. Epub 2016 May 31. PMID: 27251203
3. Steller JG, Blue RS, Burns R, Bayuse TM, Antonsen EL, Jain V, Blackwell MM, Jennings RT. Gynecologic Risk Mitigation Considerations for Long-Duration Spaceflight. Aerosp Med Hum Perform. 2020 Jul 1;91(7):543-564. doi: 10.3357/AMHP.5538.2020. PMID: 32591031.