Imaging-Centric Abdominal Multi-Omics Program (ICAMP): An Imaging-Centered Research Infrastructure for Lesion-Level Multi-Omics Integration in Precision Oncology

Preeti Ahuja, PhD, Nashla Velarde, Ziba Zokaei, David Lu, MD, & Steven Raman, MD
Department of Radiological Sciences, David Geffen School of Medicine at UCLA, Los Angeles, CA
Corresponding author: Preeti Ahuja, PhD, Pahuja@mednet.ucla.edu

Introduction and Overall Goal

Precision medicine increasingly relies on integrating diverse data modalities to characterize disease biology & guide clinical decision-making. Although advances in genomics, pathology & artificial intelligence have transformed cancer research, these data remain fragmented across clinical systems. Radiologic imaging offers a unique opportunity to serve as the central spatial & temporal framework linking tissue pathology, molecular profiling & clinical outcomes. We developed the ICAMP to establish a scalable, imaging-centered infrastructure for lesion-level multi-omics integration, initially focused on prostate cancer.

Specific Aims

- Establish lesion-level radiology-pathology correlation as a foundation for multi-omics data integration.
- Develop AI/ML models for automated lesion segmentation & radiogenomic biomarker discovery.
- Embed longitudinal biobanking (blood &tissue) & structured imaging/clinical data capture within routine clinical workflows.
- Implement governance via a Program Management Office (PMO), ensuring FAIR (Findable, Accessible, Interoperable, Reusable) data principles & regulatory compliance.
- Foster a collaborative, team-science model uniting radiologists, pathologists & data scientists around standardized workflows.

Rationale and Background

Multiparametric MRI (mpMRI), PSMA-PET & contrast-enhanced CT capture detailed spatial & temporal tumor heterogeneity, yet these imaging phenotypes are rarely linked systematically to histopathologic & genomic findings at the lesion level. Advances in image-guided biopsy, digital pathology & radiogenomics now make it feasible to bridge this gap, enabling biomarker discovery that reflects true spatial concordance between imaging & molecular data. A structured, imaging-anchored framework is needed to translate these techniques into a scalable, reproducible research infrastructure.

Methods and Materials

ICAMP integrates imaging, pathology, clinical, & molecular data within a prospective observational infrastructure embedded in routine clinical workflows, supporting standardized acquisition of mpMRI, CT, US, PET/CT, digital pathology, biospecimens, proteomics, genomics & longitudinal outcomes. Image-guided biopsies enable precise lesion-level correlation between imaging & pathology. Dedicated informatics infrastructure supports automated data extraction, de-identification, quality control & harmonization. A multidisciplinary PMO coordinates workflows among radiologists, pathologists, surgeons, oncologists, bioinformaticians & data scientists while ensuring regulatory compliance. Machine learning pipelines are being developed for automated lesion segmentation & radiogenomic feature extraction to support biomarker validation.

Results

ICAMP has established one of the largest imaging-centered, lesion-level prostate cancer research infrastructures to support translational precision oncology. The program includes **30,062 prostate mpMRI studies**, including **2,042 lesion-annotated cases**, **2,097 patients with comprehensive clinical datasets**, and **1,679 MRI-pathology matched radical prostatectomy cases** with corresponding digital pathology and clinical outcomes. Additional resources include **520 PSMA PET-pathology matched studies**, **663 patient-specific 3D mold reconstructions**, **111 ex vivo imaging cases**, **94 micro-ultrasound cases**, and **452 MRI-guided biopsy cases linked to frozen tissue cores, blood, and clinical outcomes**. Structured clinical datasets span imaging, pathology, treatment, recurrence, and longitudinal follow-up, while several thousand patients also have linked genomic information. This integrated infrastructure has enabled numerous multidisciplinary collaborations, investigator-initiated studies, several million-dollar grant submissions & more than 100 peer-reviewed publications while establishing a scalable platform for AI development and radiogenomic biomarker discovery.

Discussion and Conclusion

ICAMP demonstrates that radiologic imaging can serve as the central organizing framework for precision oncology by enabling standardized lesion-level integration of imaging, pathology, biospecimens, genomics & clinical outcomes. By combining AI-ready data architecture, robust governance & multidisciplinary collaboration, ICAMP provides a scalable model for accelerating biomarker discovery & advancing precision cancer care across prostate cancer & other abdominal malignancies. As a continuously evolving resource, the infrastructure incorporates iterative data curation, quality assurance & validation of emerging imaging modalities, tissue acquisition strategies & molecular profiling approaches to maximize scientific rigor & translational impact.