# Quantitative Imaging Research and Artificial Intelligence Lab
## Data Management Pipeline for AI Research in Radiation Oncology

**Background:**

To build AI for health care, data is required

Data has to be accessible, complete and privacy-preserved.

Radiation Oncology department has vast amounts of data

However, data is in multiple silos, sometimes in non-minable formats

We need processes to ensure data quality, mechanisms to manage data from multiple sources and privacy-preserved for AI research.

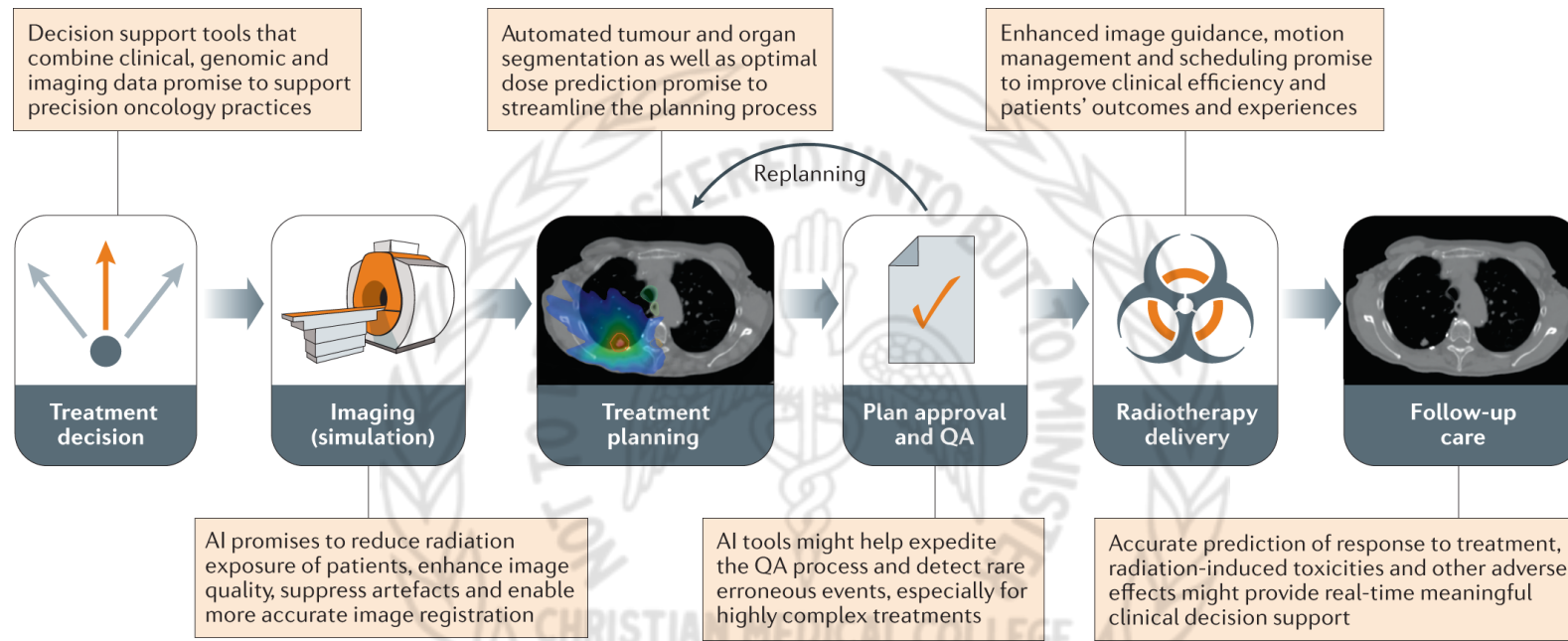**Presenter: Dr Balu Krishna S,**
Professor and Head,
Radiation Oncology Unit II, Christian Medical College Vellore
Clinical Lead: QIRAIL
CMC Vellore

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# AI in Radiation Oncology



Decision support tools that combine clinical, genomic and imaging data promise to support precision oncology practices

Automated tumour and organ segmentation as well as optimal dose prediction promise to streamline the planning process

Enhanced image guidance, motion management and scheduling promise to improve clinical efficiency and patients' outcomes and experiences

Replanning

Treatment decision — Imaging (simulation) — Treatment planning — Plan approval and QA — Radiotherapy delivery — Follow-up care

AI promises to reduce radiation exposure of patients, enhance image quality, suppress artefacts and enable more accurate image registration

AI tools might help expedite the QA process and detect rare erroneous events, especially for highly complex treatments

Accurate prediction of response to treatment, radiation-induced toxicities and other adverse effects might provide real-time meaningful clinical decision support

https://media.springernature.com/full/springer-static/image/art%3A10.1038%2Fs41571-020-0417-8/MediaObjects/41571_2020_417_Fig1_HTML.png

## PROJECT GOALS

- Develop a robust data preparation pipeline tailored for AI integration in Radiation Oncology.
- Integrate the pipeline seamlessly within existing clinical workflows.
- Ensure high-quality data curation, annotation, and storage for AI research.
- Use open-source solutions in processes for wider applicability and sustainability.
- Provide practical insights and frameworks tailored to specific contexts.

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**ROADMAP**

**2019**

**1. Research question**

- Define research objectives specific to radiation oncology
- Consider prevalent cancer types and treatment from Indian context
  - Identify relevant AI techniques to address the question
    - Disease classification, outcome prediction, risk stratification?

**2. Build an interdisciplinary team**

- Leverage diverse expertise
- E.g. Radiation oncologists, medical physicists, radiation therapists, AI experts, and data scientists

**3. Infrastructure and Resources**

- High-performance computing systems (Workstations, GPU, cloud computing), storage solutions (on -premise, cloud), and software tools tailored for specific project.

**2021**

**4. Data Collection and Curation**

- Diverse and comprehensive datasets
- Data anonymization, privacy protection, and compliance with Indian data protection laws
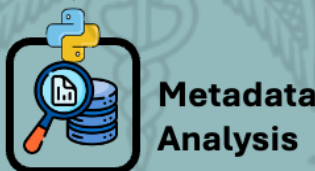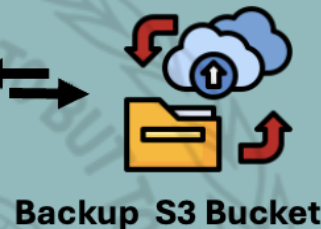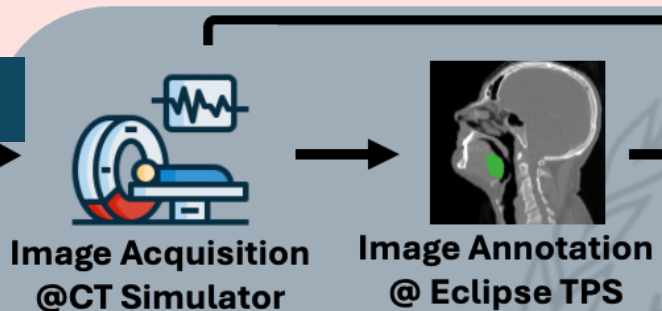
**6. Validation and Clinical Integration**

- Validate the models using external multi-centric data
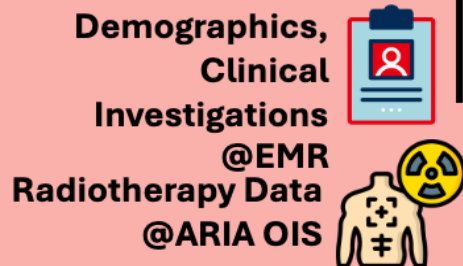- Assess impact on patient outcomes through prospective studies and clinical trials.

**2022-23**

**5. AI Model Development**

- Use appropriate machine learning, deep learning, and image analysis algorithms to develop AI models

| Before | | After |
|---|---|---|
| Explicit for Treatment | **Consent** | Explicit for treatment and data driven research |
| Disparate Sources | **Clinical Data** | Curated and Organized in RedCap |
| Non-Specific CT Protocol | **CT Acquisition** | Standardized Protocol (HNC) |
| Manual, user-defined ROI naming | **Annotation** | Guidelines, Template based naming |
| Manual, Researcher dependent | **Data privacy** | Automated, Streamlined Pseudonymization |
| Manual, Researcher maintained Private datasheets | **Transfer & Storage** | Automated, On Research Server with Private Cloud backup |
| Absent | **Streamlined Data management** | Modular, Containerized processes |

- The CT imaging protocol for HNC was standardized in 2020
- 1100+ patients were imaged since.
- 400+ eligible patients for AI - based prediction of LRC have comprehensive Clinical data curated in Redcap and imaging data on the Research Server.

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# 8 + Projects
# 5 + Collaborations
# 10 + publications

- **Modularization** of the processes into distinct, self-contained modules
- Allows standardization and low complexity
- Possibility of customization for each project and situational needs.
- **Containerization** facilitates faster deployment of the modules required for each project.
- **Sustainable by design**: Integration with the clinical environment is achieved through open-source platforms like Orthanc DICOM server and XNAT
- **Collaborative:** Good data and easy-to-use processes facilitated newer projects.
- **Scalable :** Allows deployment for multiple projects.



Can Pretreatment MRI and Planning CT Radiomics Improve Prediction of Complete Pathological Response in Locally Advanced Rectal Cancer Following Neoadjuvant Treatment?
Jeba Karunya Ramireddy, A. Sathya, Balu Krishna Sasidharan, Amal Joseph Varghese, Arvind Sathyamurthy, Neenu Oliver John, Anuradha Chandramohan, Ashish Singh, Anjana Joel, Rohin Mittal, Dipti Masih, Kripa Varghese, Grace Rebekah, Thomas Samuel Ram & Hannah Mary T. Thomas
Journal of Gastrointestinal Cancer (2024)

Is radiomics a useful addition to magnetic resonance imaging in the preoperative classification of PitNETs?
Sathya A, Abhijit Goyal-Honavar, Ari G Chacko, Anitha Jasper, Geeta Chacko, Devadhas Devakumar, Joshua Anand Seelam, Balu Krishna Sasidharan, Simon P Pavamani & Hannah Mary T Thomas
Acta Neurochirurgica (2024)

Can pre-treatment MRI and CT radiomics improve prediction of complete pathological response in locally advanced rectal cancer following neoadjuvant treatment?
Jeba Karunya Reddy, A Sathya, Amal Joseph Varghese, Arvind Sathyamurthy, Neenu Oliver John, Anuradha Chandramohan, Ashish Singh, Anjana Joel, Rohin Mittal, Dipti Masih, Kripa Varghese, Thomas Samuel Ram, Hannah Mary T Thomas
This is a preprint (2024)

Reproducibility in Radiomics: A Comparison of Feature Extraction Methods and Two Independent Datasets
Hannah Mary T. Thomas, Helen Y. C. Wang, Amal Joseph Varghese, Ellen M. Donovan, Chris P. South, Helen Saxby, Andrew Nisbet, Vineet Prakash, Balu Krishna Sasidharan, Simon Pradeep Pavamani, Devakumar D., Manu Mathew, Rajesh Gunasingam Isiah and Philip M. Evans
Applied Sciences (2023)

Multi-centre Radiomics for prediction of recurrence following Radical Radiotherapy for Head and Neck Cancers: Consequences of feature selection, machine learning classifiers and batch-effect harmonization
Amal Joseph Varghese, Varsha Gouthamchand, S. Balu Krishna, Leonard Wee, Sharief K. Sidhique, Julia Priyadarshini Rao, Andre Dekker, Frank Hoebers, D. Devakumar, Aparna Irodi, Timothy Peace Balasingh, Henry Finlay Godson, T. Joel, Manu Mathew, Rajesh Isiah, Simon Pavamani, T. Hannah Mary Thomas
Physics and Imaging in Radiation Oncology (2023)

Quantum of Corneal Scarring Calculation by Image Analysis of Anterior Segment OCT Images
Cassandra D Solomons, Ammu Anna Mathew, Karthikeyan V, Vivekanandan Shanmugasundaram, Hannah Mary Thomas, A Sathya, Jeyanth Rose
IEEE (2022)

Radiation and immune checkpoint inhibitor-mediated pneumonitis risk stratification in patients with locally advanced non-small cell lung cancer: role of functional lung radiomics?
Hannah M. T. Thomas, Daniel S. Hippe, Parisa Forouzannezhad, Balu Krishna Sasidharan, Paul E. Kinahan, Robert S. Miyaoka, Hubert J. Vesselle, Ramesh Rengan, Jing Zeng & Stephen R. Bowen
Discover Oncology (2022)

Utility of Mid-treatment DWI in Selecting Pathological Responders to Neoadjuvant Chemoradiotherapy in Locally Advanced Esophageal Cancer
Neenu Oliver John, Aparna Irodi, Hannah Mary T. Thomas, Vijay Abraham, Balu Krishna Sasidharan, Subhashini John & Simon P. Pavamani
Journal of Gastrointestinal Cancer (2022)

Can CBCT-Based Delta Radiomics Predict Normal Lung Toxicity during Thoracic Radiation?
N. Jose, A.J. Varghese, H.M. Thomas, A. Irodi, J.C. Paul, M. Mathew, R. Isiah, S. John, H.F. Godson, T.B. Peace, S.P. Pavamani, D. Devadhas, B.K. Sasidharan
International Journal of Radiation Oncology - Biology - Physics (IJROBP) (2022)

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