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Precision Oncology: How Imaging is Transforming Cancer Diagnosis and Treatment

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Università Cattolica del Sacro Cuore

GART
Advanced Radiation Therapy

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I do not have any conflict of interest to disclose

Table of contents

- Imaging trends
- Medical Imaging in personalized medicine
- Biobanks and Imaging biobanks
- Hybrid radiologist - the diagnostician
- Conclusion

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- Biobanks and Imaging biobanks
- Hybrid radiologist - the diagnostician
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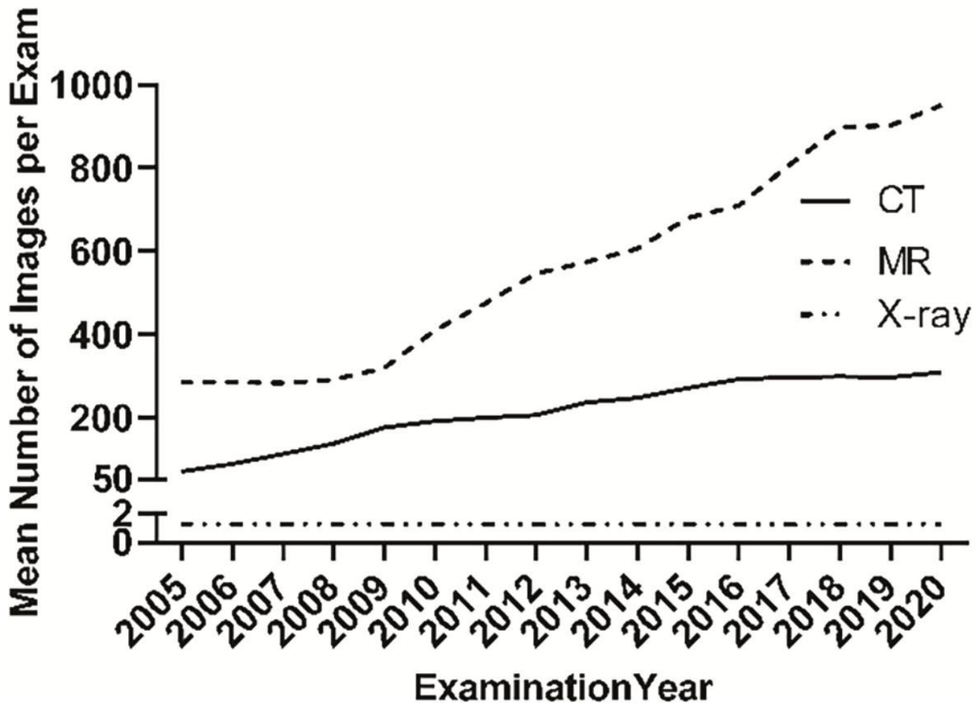
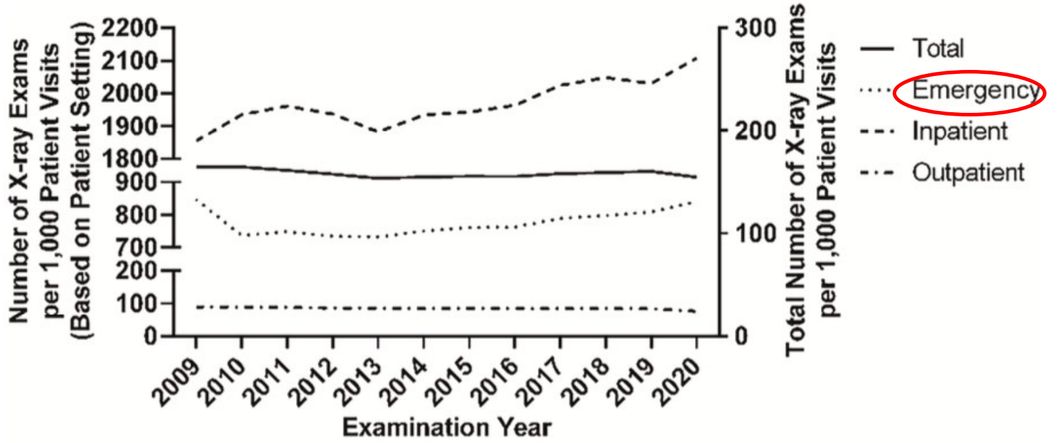
Imaging trends

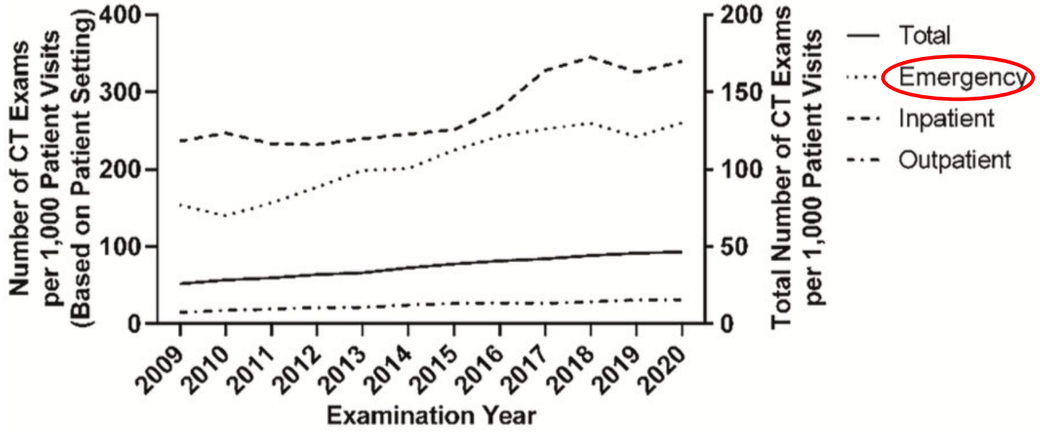
- The utilization of advanced imaging techniques (CT and MR) has grown considerably over the past two decades

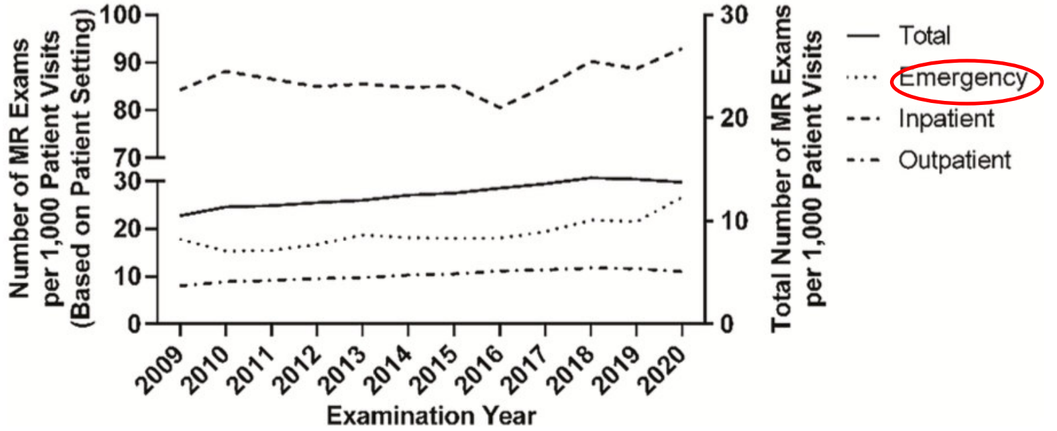


- It's a consequence of the trend of a more precise, less invasive approach to improve patient care

C. Peng, EJR 2022

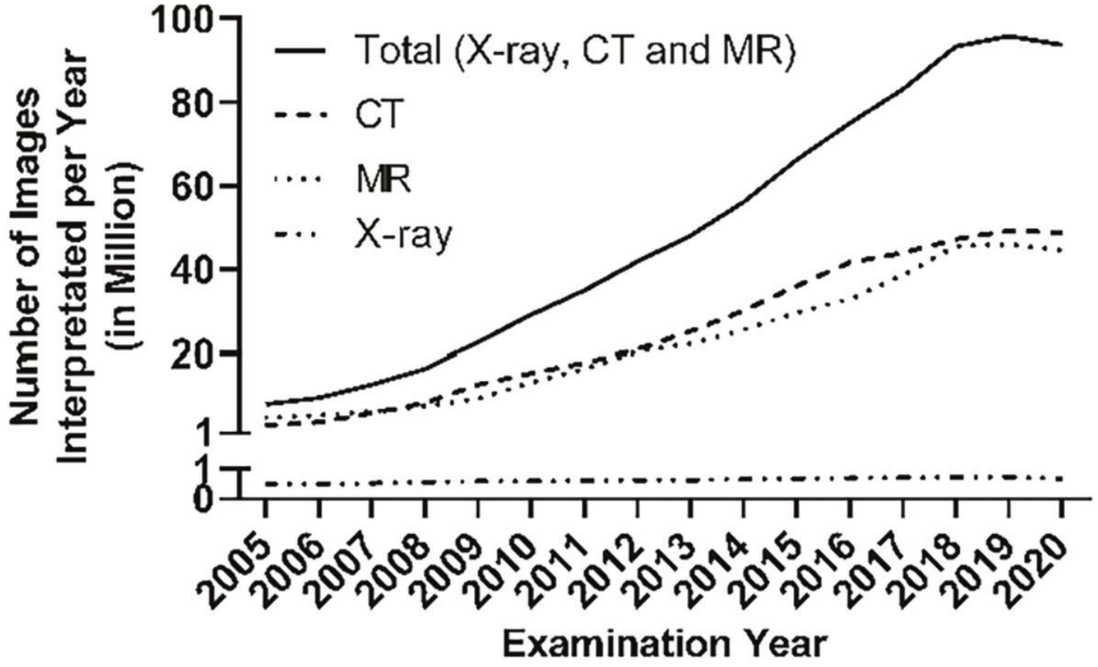




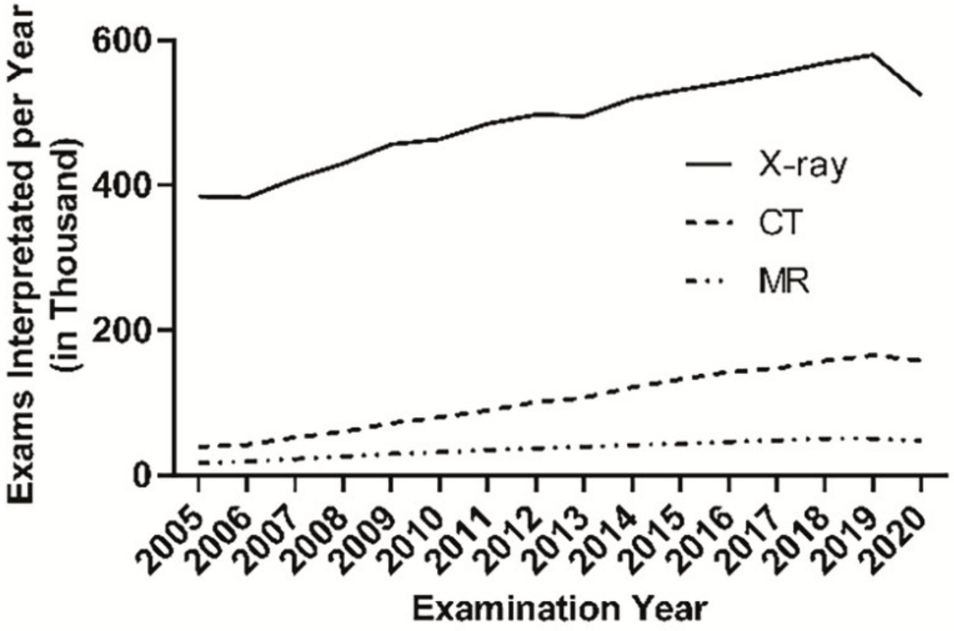


Imaging trends

- Overall increase in imaging utilization → an increase in the image interpretation workload of radiologists



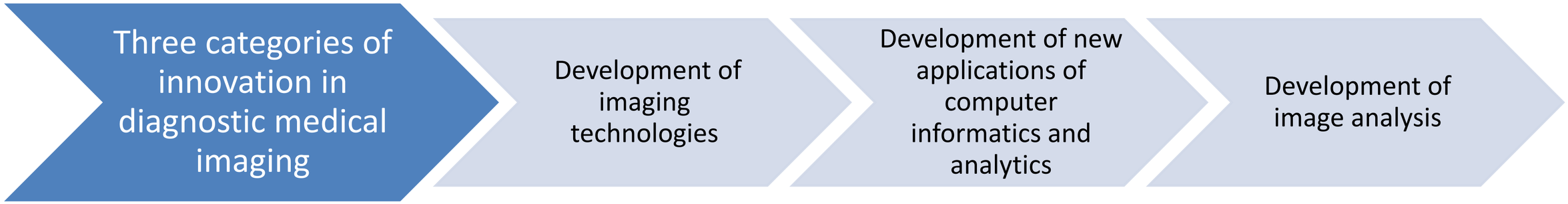
- It not only contributes to radiologist burnout but also compromises patient safety and sustainability



C. Peng, EJR 2022

Imaging trends

Health reform era: patient-centered care at higher quality and lower cost



J. Thrall, Radiology 2016

Imaging trends

Development of imaging technologies

- Faster imaging with better resolution and lower radiation exposure
- Development of “special use” devices (such as “laptop” US systems important in developing countries or the ability to “move technology to the patient.”)
- Development of more complex devices for multipurpose use, (hybrid imaging devices PET/TC, PET/MRI)

J. Thrall, Radiology 2016

Imaging trends

Development of informatics and analytics

Radiology has been a pioneer in the digital transformation of medicine, using data mining to turn big data into new insights

Decision support systems can help standardize practices, reduce variability, and improve quality of care

J. Thrall, Radiology 2016

Imaging trends

Development of image analysis

To extract as much information—medical value—as possible from the acquired data

This is achieved through the use of various methods: radiomics; deep learning systems

J. Thrall, Radiology 2016

Table of contents

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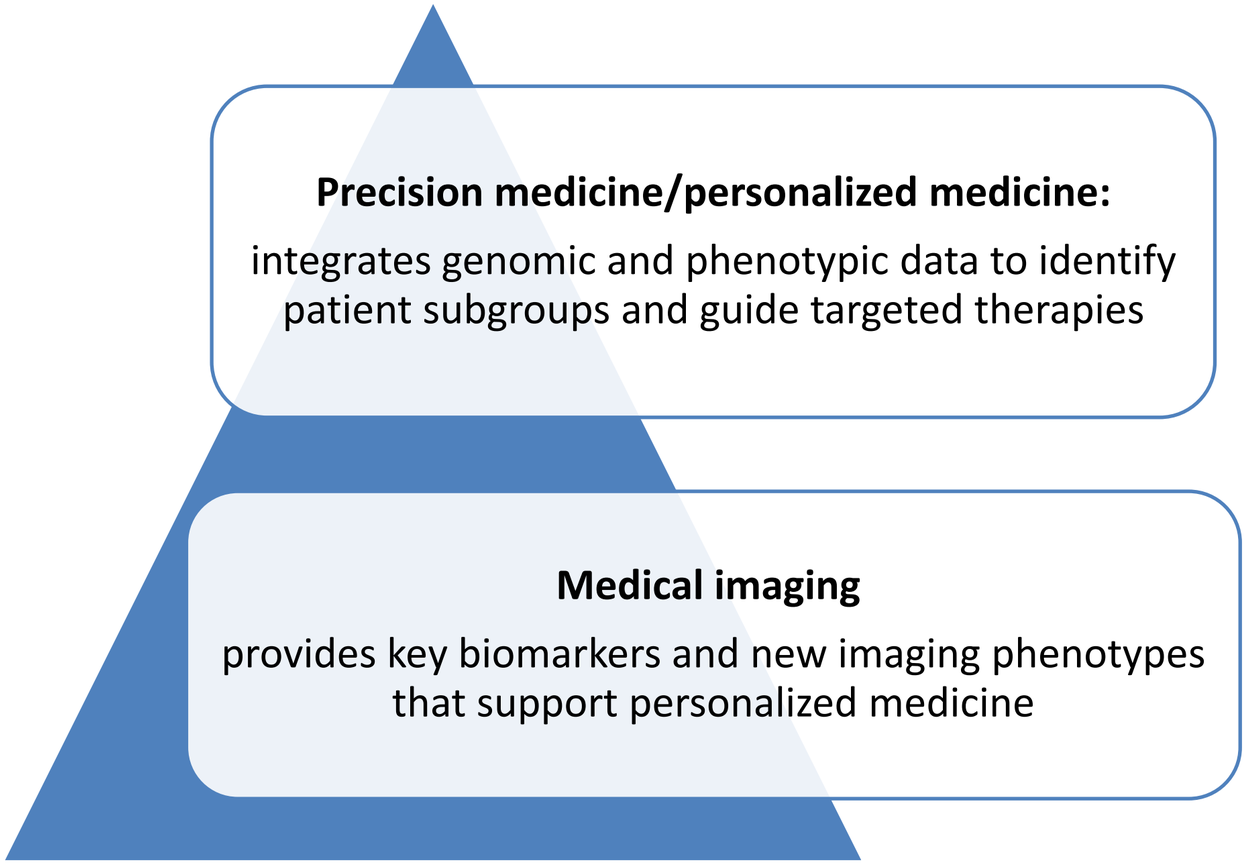
Medical Imaging in personalized medicine



J. Thrall, Radiology 2016

Medical Imaging in personalized medicine

Insights Imaging (2011) 2:621–630
DOI 10.1007/s13244-011-0125-0

STATEMENT

Medical imaging in personalised medicine: a white paper of the research committee of the European Society of Radiology (ESR)

European Society of Radiology

2011 ESR white paper –medical imaging is integral to personalised medicine: it allows early diagnosis, localisation of disease and patient-tailored therapies.

Insights Imaging (2015) 6:141–155
DOI 10.1007/s13244-015-0394-0

STATEMENT

Medical imaging in personalised medicine: a white paper of the research committee of the European Society of Radiology (ESR)

European Society of Radiology (ESR)

2015 ESR update – Reaffirms imaging's central role.

Image-based: screening, guide treatment choices; therapy response.

New concepts introduced – *radiomics*, *radiogenomics,* linking imaging features to genetic/molecular characteristics for improved personalised diagnosis and prognosis

Innovations for precision medicine – large imaging biobanks linked to genomic and other "-omics" data to enable integrated multi-omic analyses.

Medical Imaging in personalized medicine

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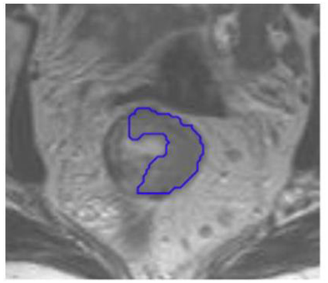
Radiomics

Introduced in 2012

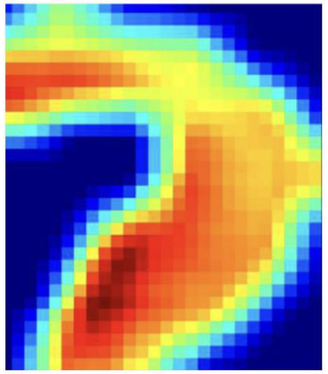
Process of extracting quantitative features (imaging biomarkers) from diagnostic images.

- **Treatment monitoring** and **outcome prediction**.
- **Predict treatment response**, **metastatic risk**, and **patient survival**.
- Improve **prognostic accuracy**.

1) Segmentation



2) Features extraction



3) Texture analysis report

Autocorrelation	960	Maximum probability	0.01
Cluster prominence	311282.70	Sum average	60.01
Cluster Shade	1012.60	Sum Entropy	4.08
Contrast	51.24	Sum os Square Variance	82.21
Correlation	0.70	Sum Variance	293.27
Difference Entropy	2.66	Kurtosis	3.76
Difference Variance	22.01	Skweness	0.16
Dissimilarity	5.34	Pixel Intensity Means	147.06
Energy	0.00	Pixel Intensity Std.	30.82
Entropy	5.63	Pixel Intensity Median	145
Homogeneity	0.18	Pixel Intensity P25	129.75
Information measure of Correlation 1	-0.40	Pixel Intensity P75	164
Information measure of Correlation 1	0.97	D2D	1.42

Neri E, INSI 2018

Medical Imaging in personalized medicine

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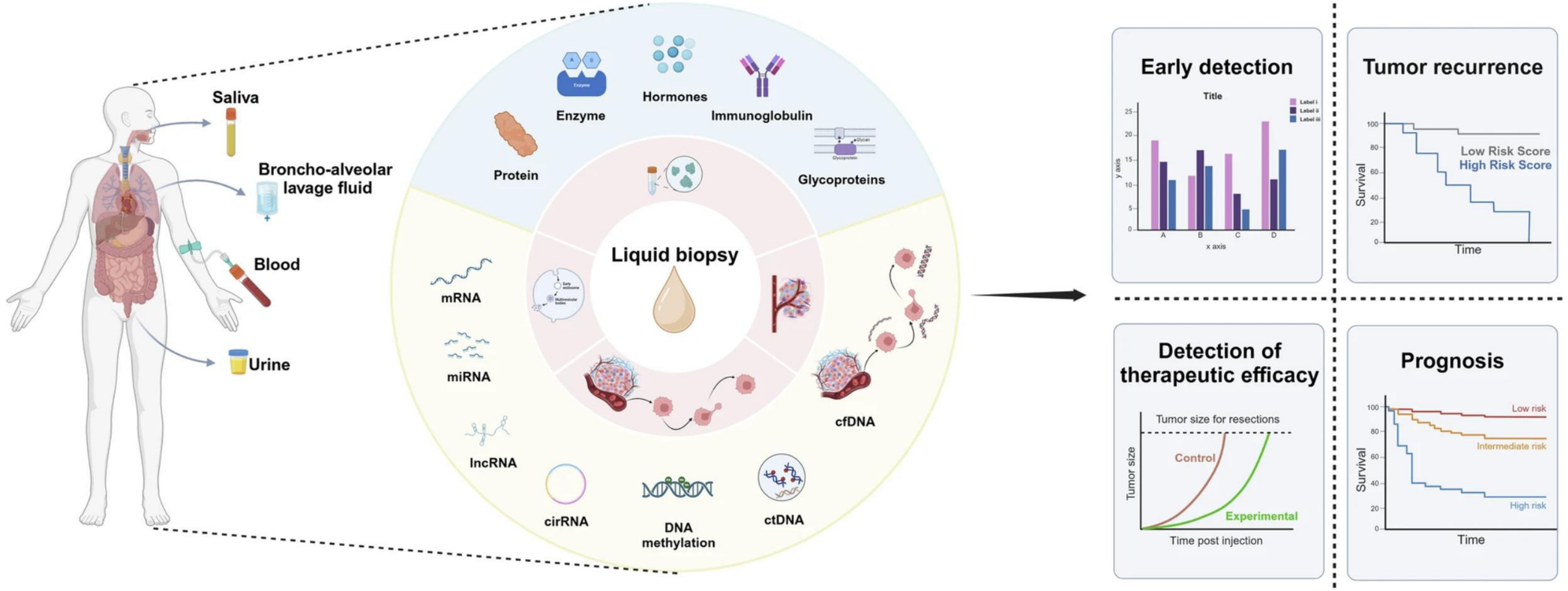
Liquid biopsy

Introduced in 2016

- Valid alternative to tissue biopsy, a surrogate source of tumour DNA to monitor disease progression
- Predictive and prognostic biomarkers to obtain real-time imaging of tumour dynamics



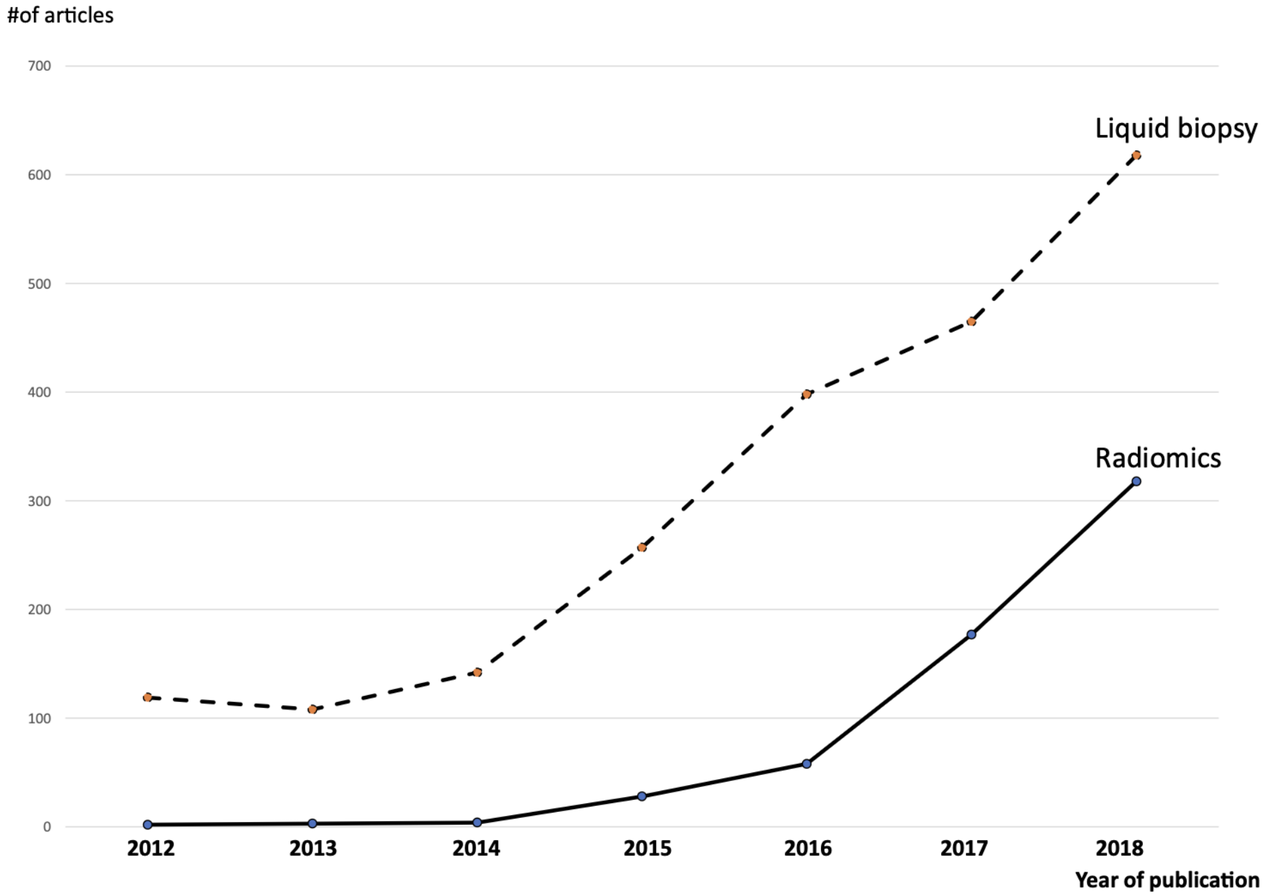
Ma L, Nature 2024

Medical Imaging in personalized medicine

- **Radiomics + liquid biopsy** provide early, minimally invasive insights by linking imaging phenotypes and molecular changes.

- Their **combined use** is applied to **screening, follow-up, and prediction of recurrence and progression**, enhancing clinical decision-making.

- The most effective way to integrate **radiomic signatures** and **liquid biopsy** is through their joint collection in **biobanks**



Neri E, INSI 2018

Table of contents

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Biobanks and Imaging biobanks

Structured repositories for the storage of biological samples of a large number of subjects

Standardized medical images (MRI, CT, US, PET, mammography) linked with clinical, molecular, and outcome data.

Radiologist's role:

- Defining and harmonizing acquisition protocols to ensure data comparability.
- Guaranteeing image quality
- Providing annotations and segmentations (ground truth for AI and radiomics).
- Integrating imaging with molecular and clinical information.

ESR, INSI 2015

Biobanks and Imaging biobanks

EUROPEAN SOCIETY OF RADIOLOGY

Survey

Table 1 Results of the ESR survey on imaging biobanks

Purpose of the biobank	Number (percentage
Research	14 (82.4)
Clinical reference	12 (70.6)
e-learning	9 (52.9)
Other	1 (5.9)
Types of cases available	
Oncologic	13 (76.5)
Cardiovascular	8 (47.1)
Healthy volunteers	7 (41.2)
Rare diseases	6 (35.3)
Other	6 (35.3)
Number of cases available	
Less than 300	5 (29.4)
300–500	3 (17.6)
500–1000	3 (17.6)
1000–2000	1 (5.9)
More than 2000	5 (29.4)
Kind of imaging data available	
Computed tomography	14 (82.4)
Magnetic resonance	15 (88.2)
Hybrid imaging	5 (29.4)
Ultrasound	9 (52.9)
Other	5 (29.4)
Availability of follow-up image examinations	
Not available	5 (29.4)
Available	12 (70.6)
Accessibility to the biobank	
Fully open on the Internet	1 (6.3)
Open to any registered user (free registration)	2 (12.5)
Restricted to users involved in predefined projects	5 (31.3)
Restricted to the personnel of the local department/hospital	8 (50.0)
Imaging data supported	
Strictly limited to acquired images	5 (31.3)
Also contains processed images (segmentation, registration, etc.)	8 (50.0)
Also contains imaging biomarkers	3 (18.8)
Image formats	
Strictly limited to DICOM	13 (81.3)
DICOM and other common formats used in research (such as NIFTI, Analyze)	1 (6.3)
Also contains imaging biomarkers	2 (12.5)

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ESR, INSI 2015

EUCAIM

EUCAIM

WEBSITE

https://cancerimage.eu/

Building a Data-Driven Future for Cancer Care

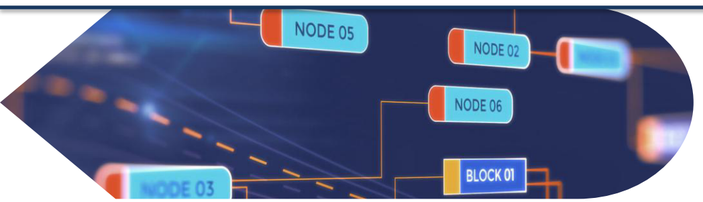
95 partners from 17 countries

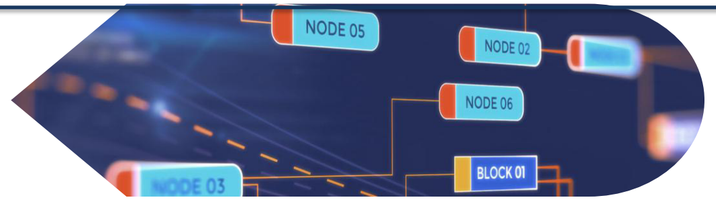
Impact:

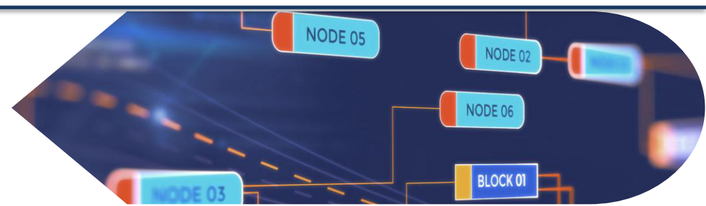
- Standardisation
- Data Integration
- Training
- Standard Technical Infrastructure

The project aims:

- **revolutionize cancer diagnosis** and **treatment** by using data and AI;
- **reduce disparities** and ensure **equal access** to high-quality care, while harmonizing data exchange across Europe







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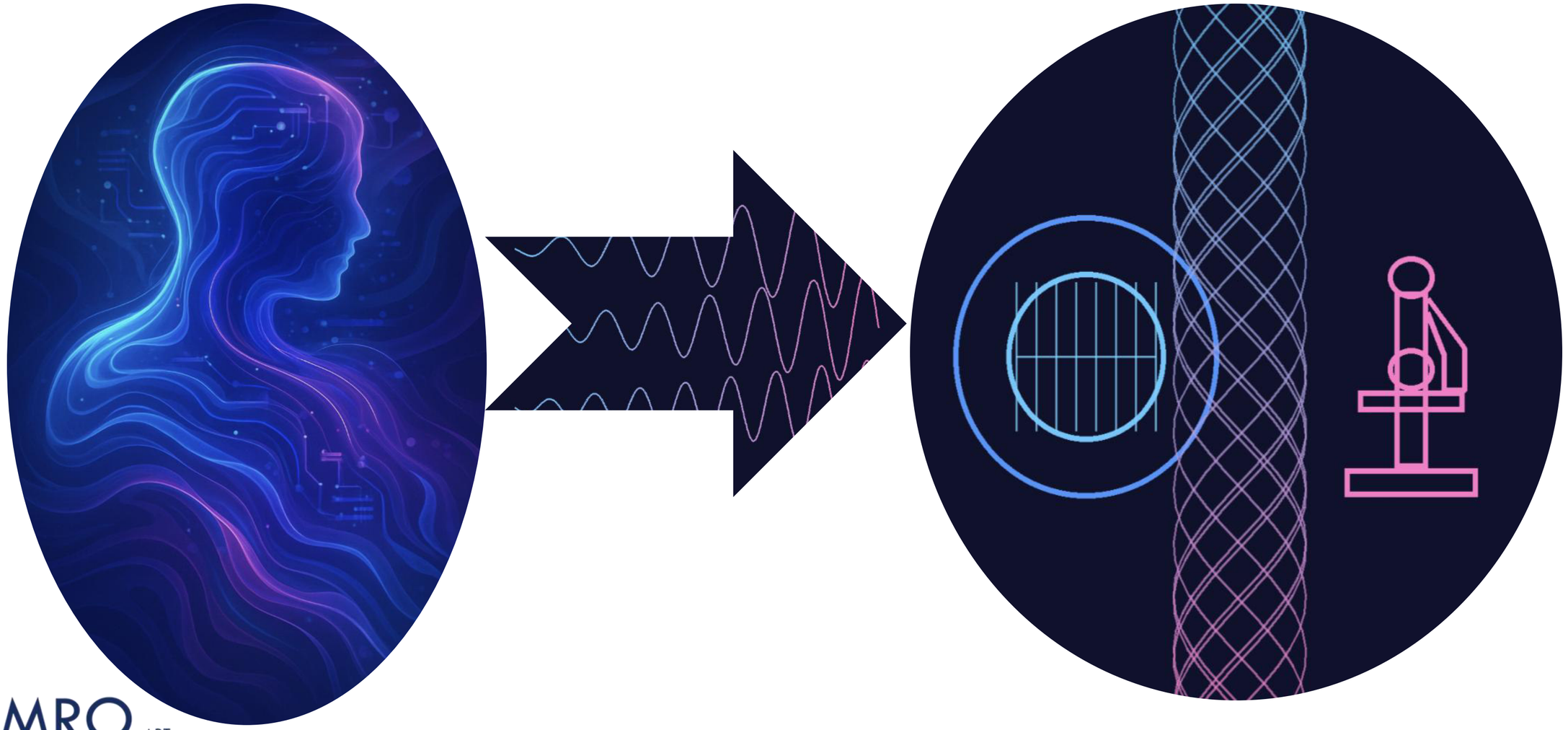
Hybrid radiologist



Integrated diagnostic model

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Hybrid radiologist

The time is now for postgraduate course in

Rad + NM + RT

=

RADIOLOGICAL SCIENCES

Integrated diagnostic model

Hybrid radiologist - the diagnostician

” Diagnostician”
a physician trained in both imaging and pathology

It is a necessary evolution in response to the demands of precision oncology, adaptive radiotherapy, and personalized medicine

A new specialty would require a new curriculum that blends competencies from both radiology and pathology, molecular diagnostics and AI literacy

Sala E, EJR 2025

Hybrid radiologist - the diagnostician

Training reform for the diagnostician specialty

Component	Description
Unified Curriculum Design	Combines core competencies from radiology, pathology, molecular diagnostics, and AI literacy.
Integrated Residency	5–6 year program with rotations in radiology, pathology, oncology, informatics; dual mentorship and interdisciplinary experience.
Fellowship Opportunities	Subspecialties in Oncologic Diagnostics, AI-Augmented Diagnostics, Molecular Imaging & Pathology, Digital Health & Informatics.
Certification & Accreditation	Joint pathways via ABR and ABP or a new Board of Diagnostic Medicine.
Continuing Medical Education (CME)	Covers AI ethics, bias mitigation, biomarkers, adaptive therapy, and integrated reporting standards.

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Conclusion

- Innovations in medical imaging have expanded measurable parameters, moving radiology beyond traditional anatomy into physiology, metabolism, and cellular and molecular biology.

- The imaging community must focus not only on the accuracy of new methods but also on their ability to improve patient-centered care, outcomes, and cost-effectiveness.

- AI is a powerful augmentation.

Conclusion

- The hybrid radiologist is not just a technological possibility, it is a clinical necessity for supporting the development of personalized therapies.

- Systemic change is needed: new training programs, redefined roles, and a reimagined healthcare infrastructure.

- Healthcare systems should actively consider and prepare for this!

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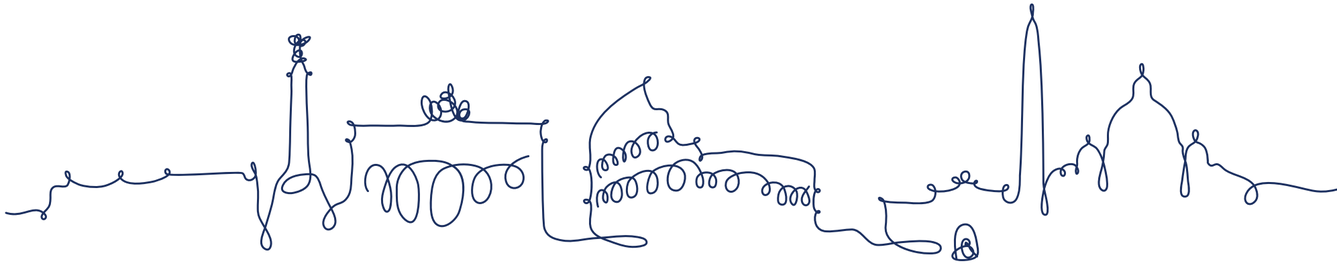

Thanks for your attention

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MRO.35: Equity and research in oncology. The subtle balance between personalized medicine and accessibility to care

26-27-28 OCTOBER 2025 - Fondazione Policlinico Universitario A. Gemelli IRCCS

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