MEDICAL UNIVERSITY OF VIENNA

Machine Learning in Clinical Reality

Georg Langs

Medical University of Vienna

Department for Biomedical Imaging and Image-guided Therapy

Computational Imaging Research Lab

CAIM - Comprehensive Center for AI in Medicine

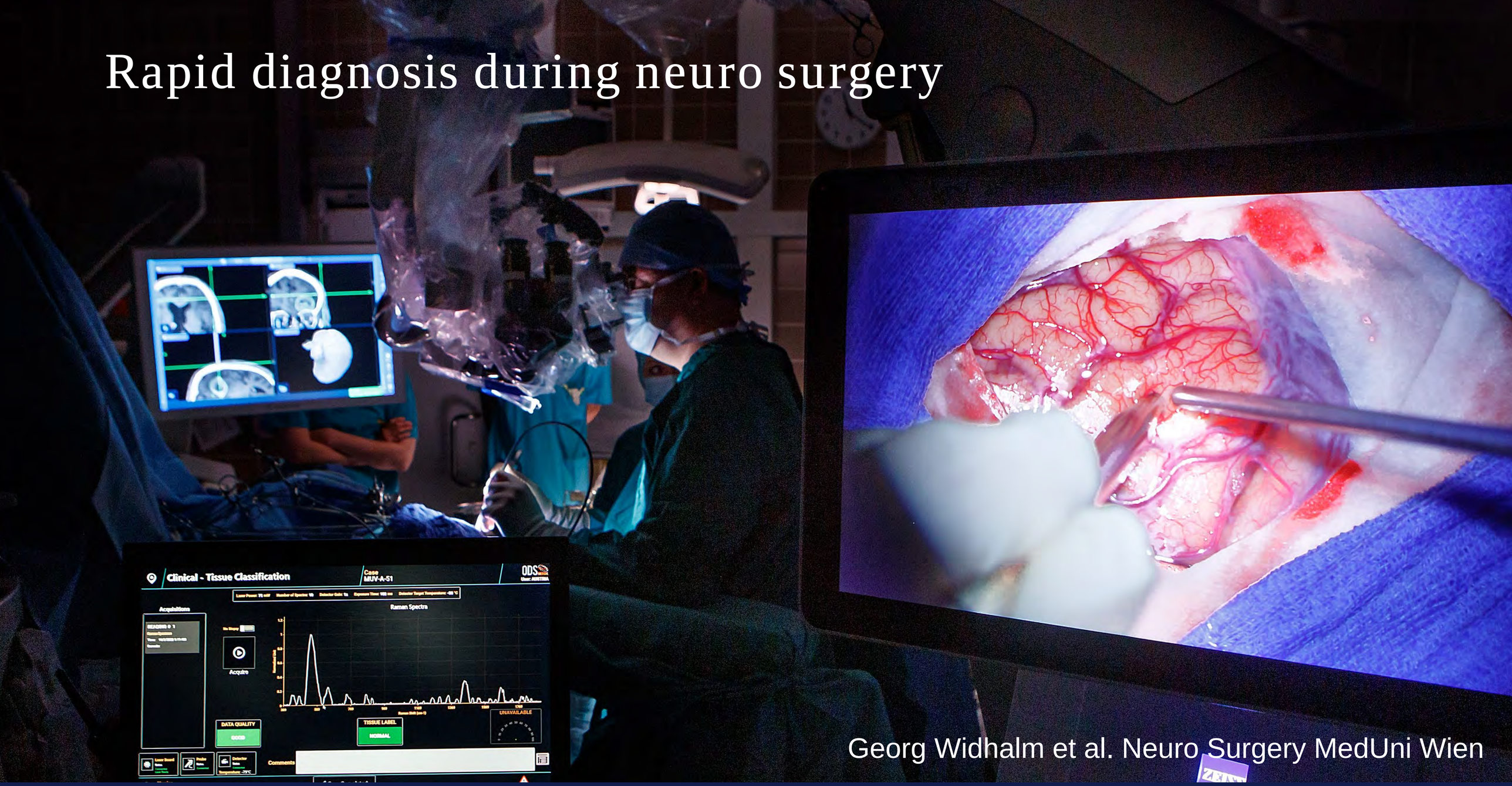
Disclosure

Co-founder, shareholder: contextflow GmbH

Research grants: Siemens Healthineers, Novartis, Boehringer Ingelheim, NVIDIA

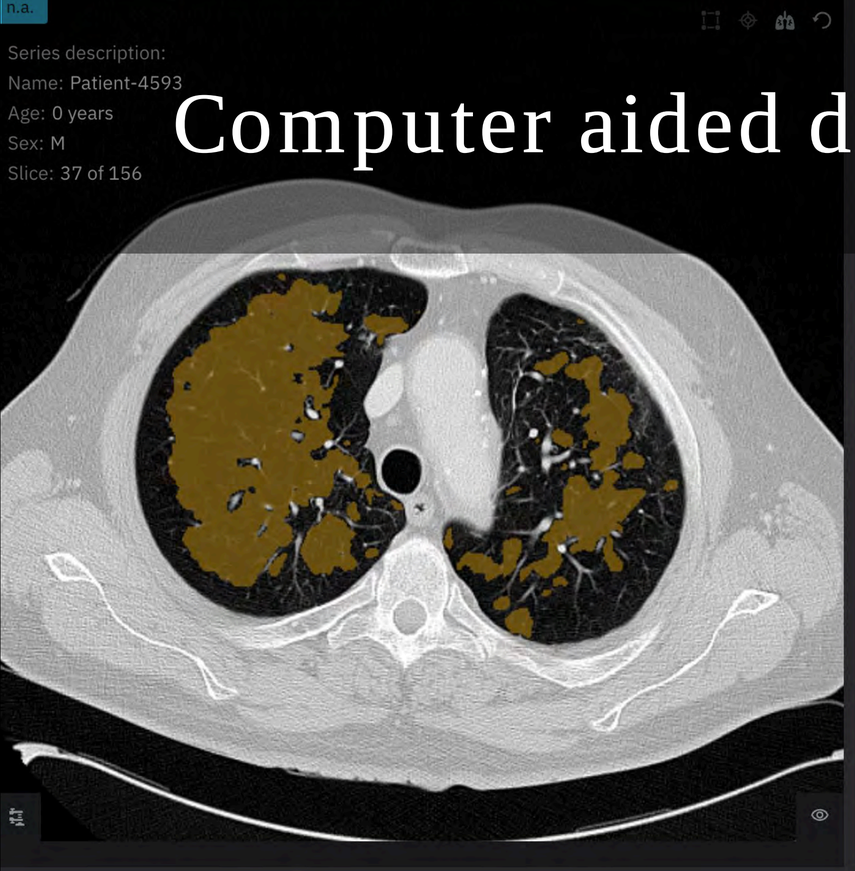
Honoraria: Roche

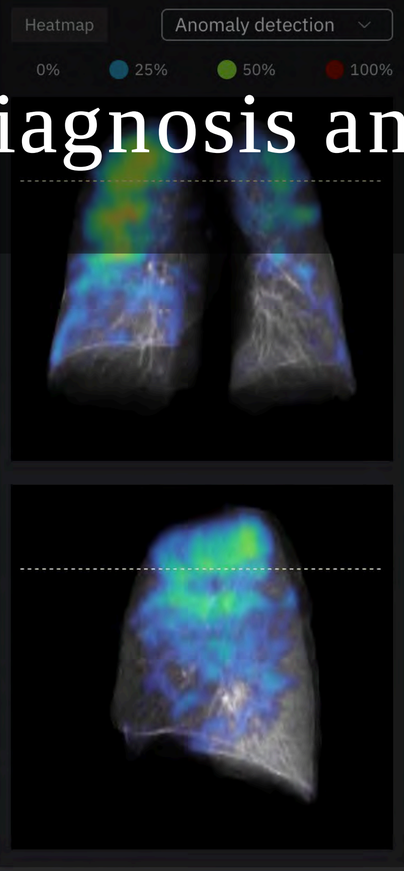
Rapid diagnosis during neuro surgery

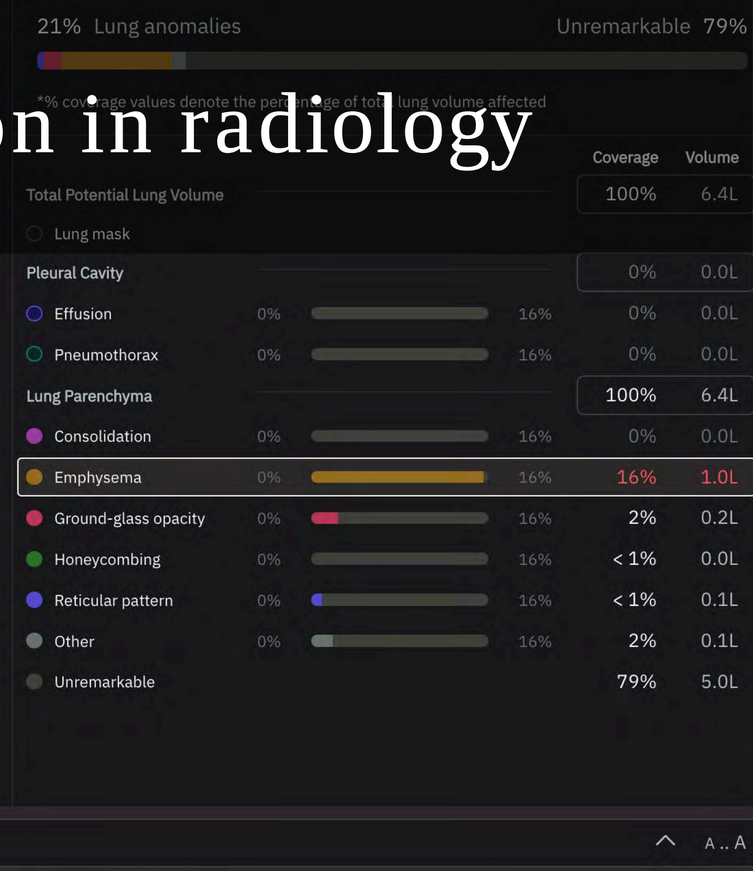


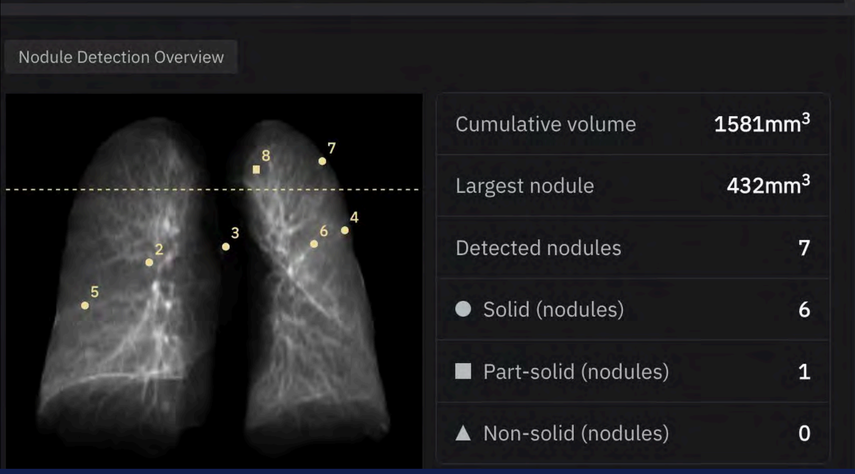
Georg Widhalm et al. Neuro Surgery MedUni Wien

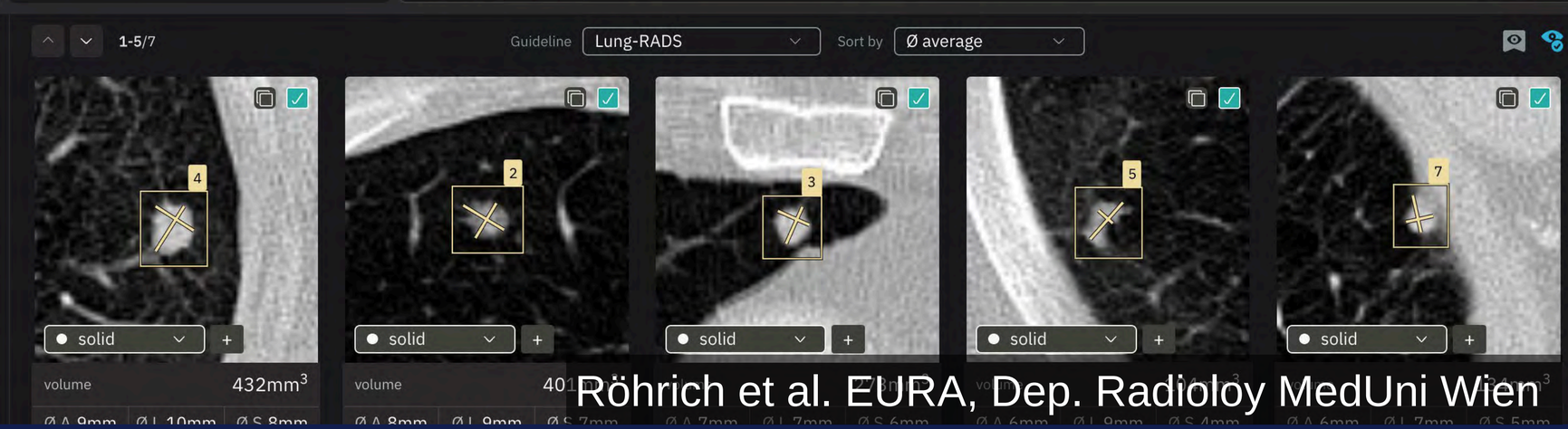
Computer aided diagnosis and quantification in radiology







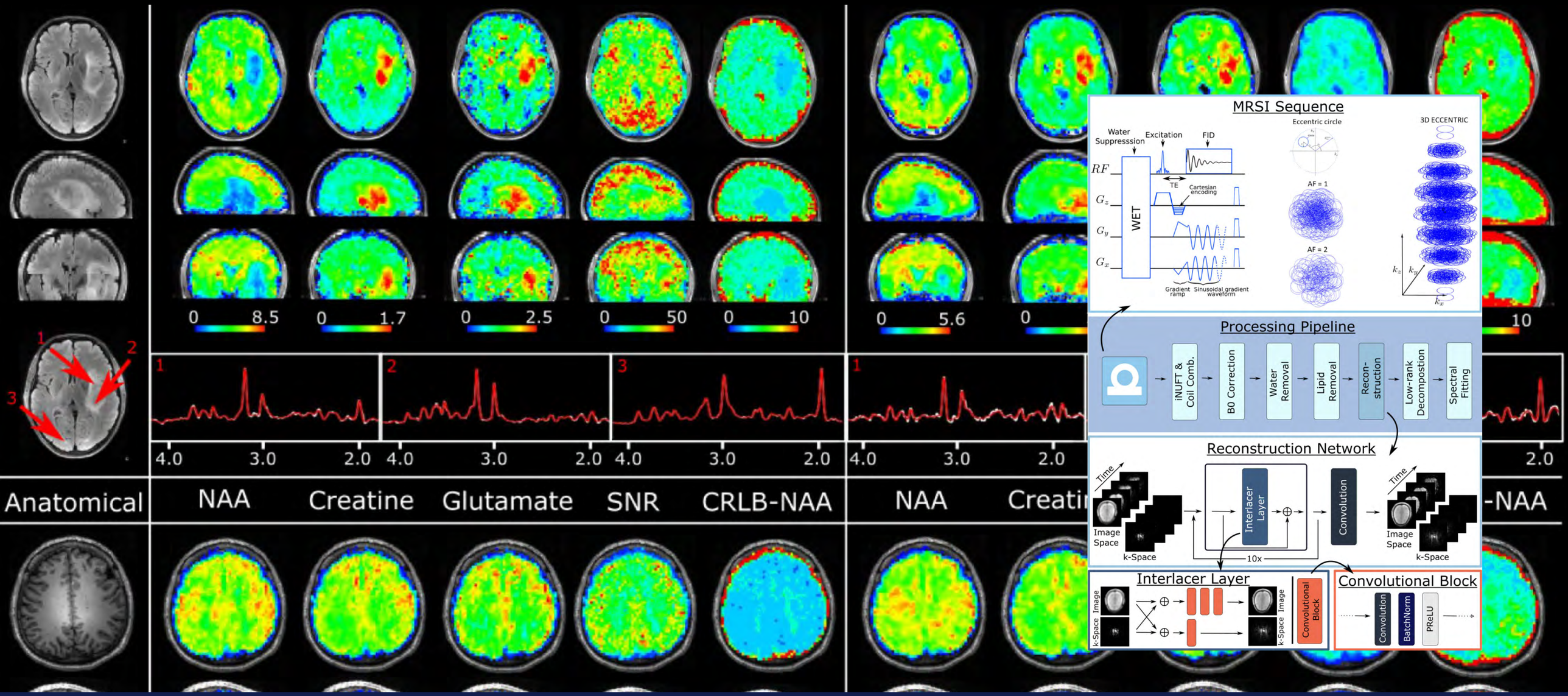




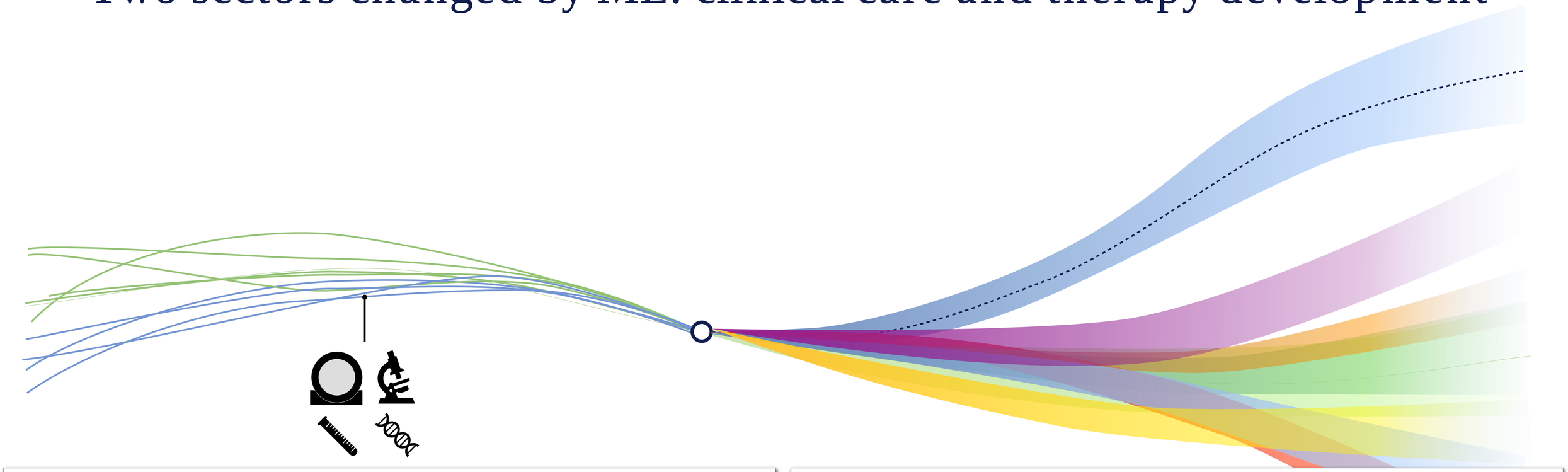
Röhrich et al. EURA, Dep. Radioloy MedUni Wien

Weiser et al. 2025 https://doi.org/10.1016/j.neuroimage.2025.121045

Reconstructing MR spectroscopy imaging with DL



Two sectors changed by ML: clinical care and therapy development



A. ML to treat individual patients

- Predict disease course
- Predict response to treatment
- Optimal patient management
- Early intervention and prevention

B. ML to develop novel therapies

- Novel fine-grained early digital endpoints
- Patient stratification
- Biology, hypotheses, and therapeutic targets
- Identify phenotypes in real world populations

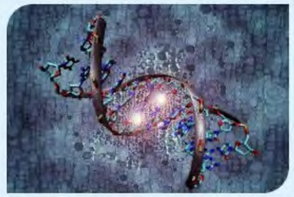
COMPREHENSIVE CENTER FOR ARTIFICIAL INTELLIGENCE IN MEDICINE
MEDICAL UNIVERSITY OF VIENNA

Speech and hearing science

Philipp Aichinger

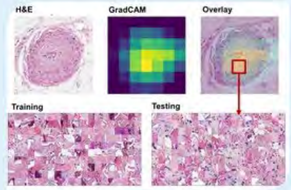
Dynamics of neural systems

Adam Gosztolai



Machine learning in biomedicine

Christoph Bock

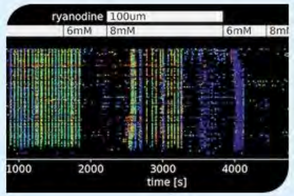


Dermatologic imaging and informatics

Philipp Tschandl
Harald Kittler

Clinical pathways and health services

Dominik Roth



Cell and tissue networks

Marjan Slak Rupnik

Applied quantum computing

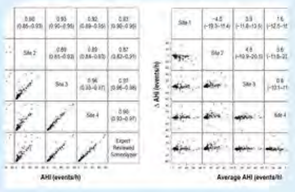
Laszlo Papp

Brain cellular heterogeneity

Roman Romanov

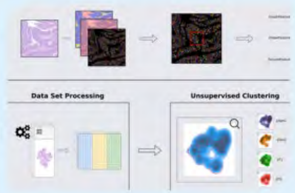
Ophtalmic image analysis

Hrvoje Bogunovic



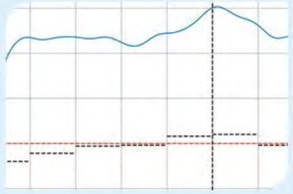
ML for prediction and signal processing

Georg Dorffner



Computational pathology

Christopher Kaltenecker

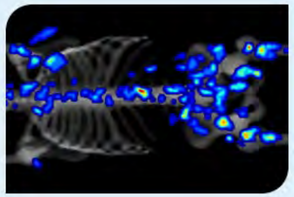


Intensive care and anestesia

Oliver Kimberger

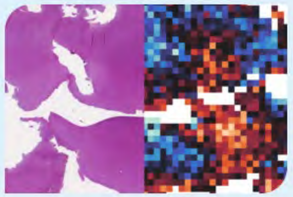
Trustworthy artificial intelligence

Matthias Samwald



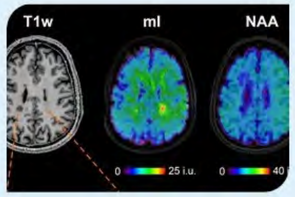
Computational imaging research

Georg Langs



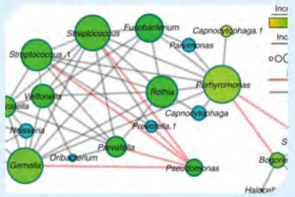
Computational neuropathology

Adelheid Wöhrer



Metabolic MR imaging

Wolfgang Bogner



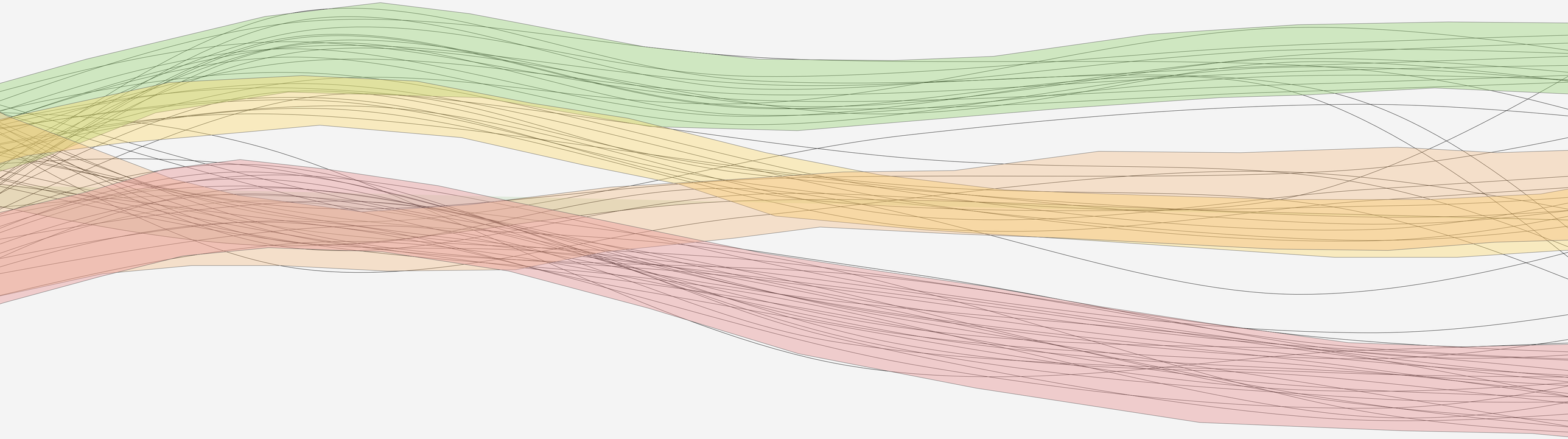
Multi-omics microbial systems

Stephanie Widder

- **Integration**: clinical real world use & biomedical research & machine learning development
- **Recruiting**: attractive center with 25 labs, 150 researchers across all discriplines
- ***Dicke Bretter* are still open:** robustness, explainability, learn from few patients, biological mechanisms

Agenda

- **Expanding role of AI** in real world data use
- **Adoption in the clinic** and value propositions of AI
  - Efficiency
  - Quality of diagnosis
  - Downstream impact on patient pathways
- **Agentic AI in healthcare** - robustness and deeper integration
- **Implementing AI** in the live clinical environment

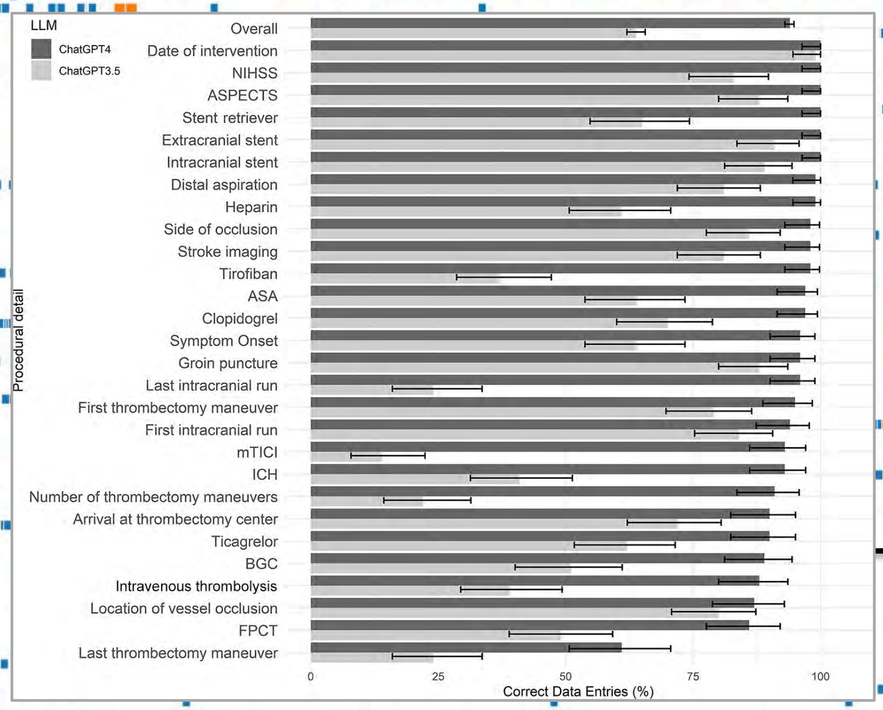


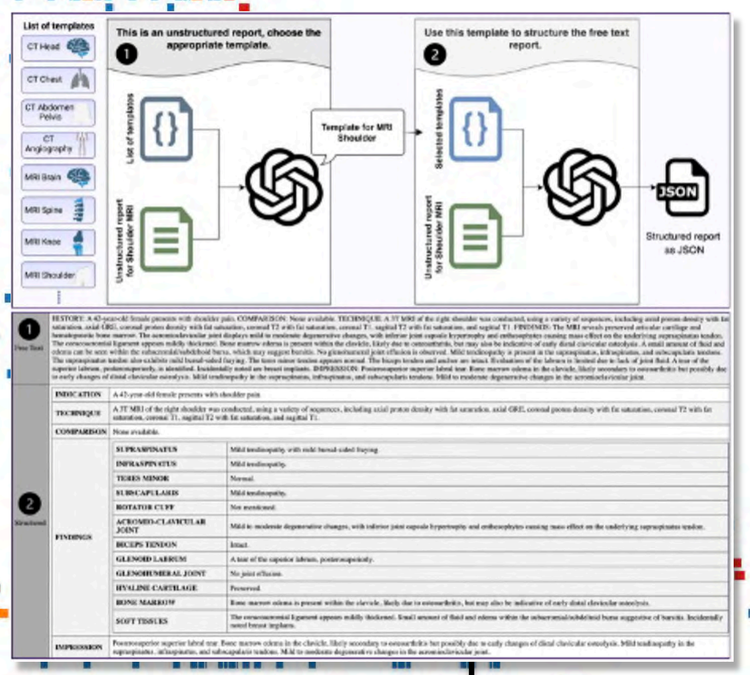
Learning from real life clinical data

Scaling to 100k patient evidence, capturing diversity and heterogeneity

Large scale real life data

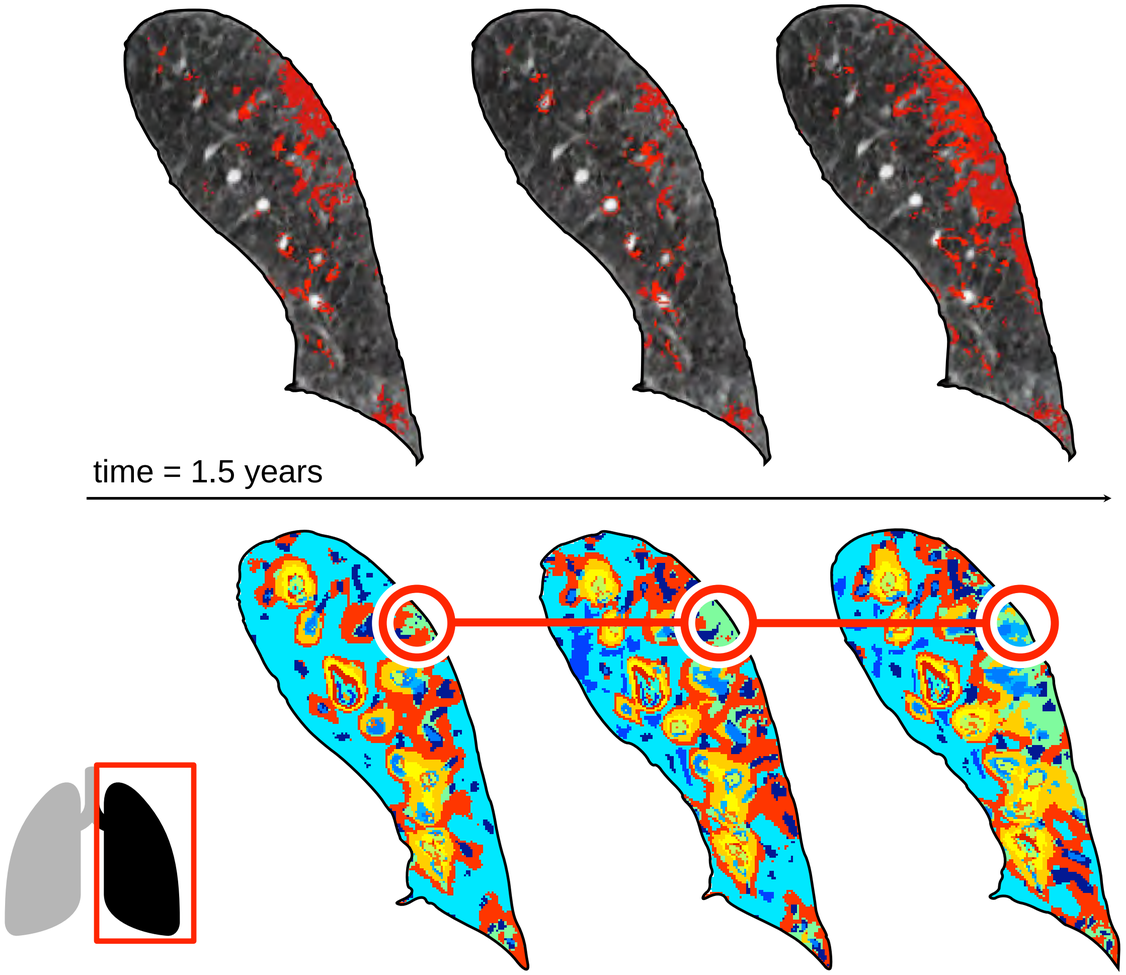
Scale ~100k patient trajectories
Ability to process unstructured data





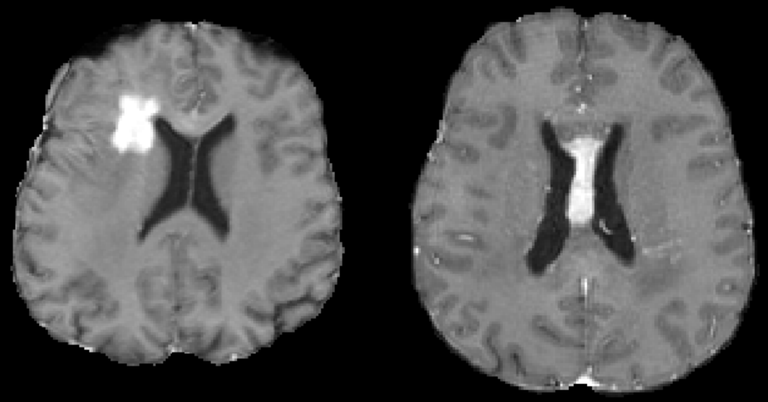
Lehnen et al. Radiology 2024, Adams Radiology 2023, Rahsepar Radiology 2023

Discover transition pathways in interstitial lung disease

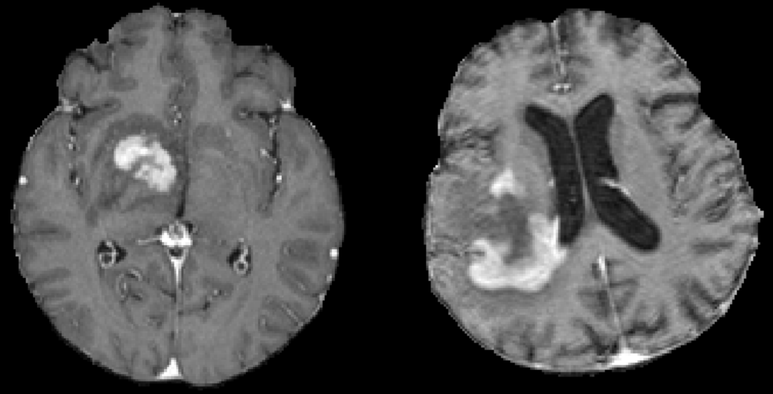


Vogl, Prosch, Ofner et al. MICCAI 2014, Pan et al. 2022 European Radiology

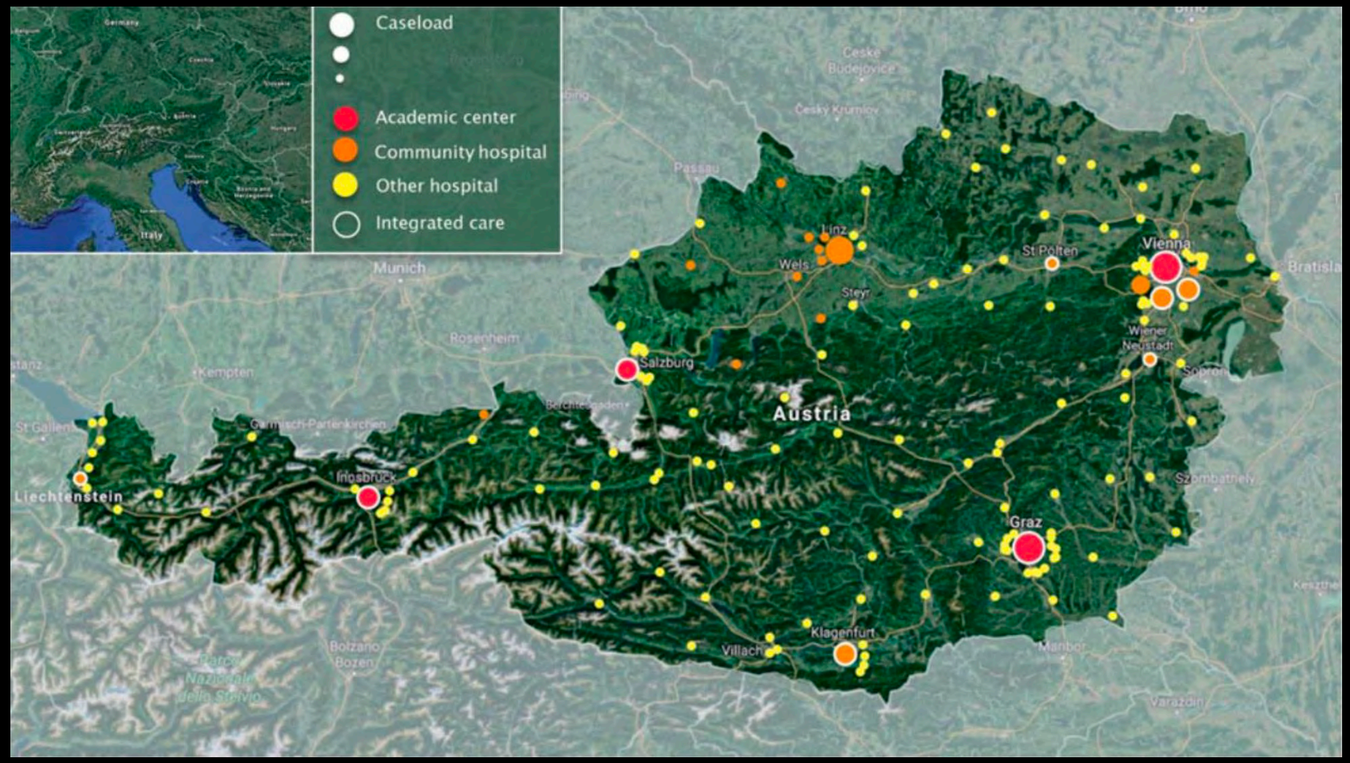
From bedside to bench: linking imaging and epigenomics



low risk: median survival 53.23 months



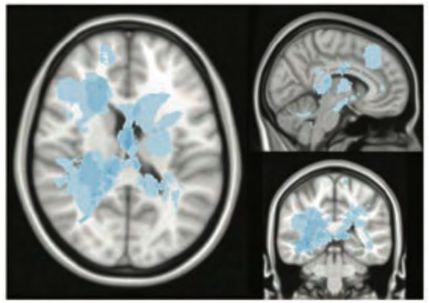
high risk: median survival 3,30 months

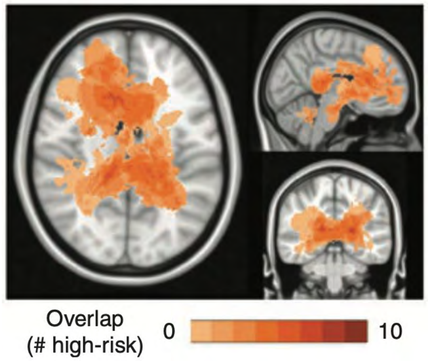


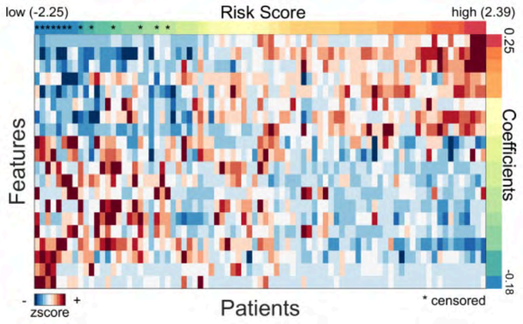
10 centers - 164 patients - ABTR Primary CNS Lymphoma Study
Validation: 1 center - South Korea

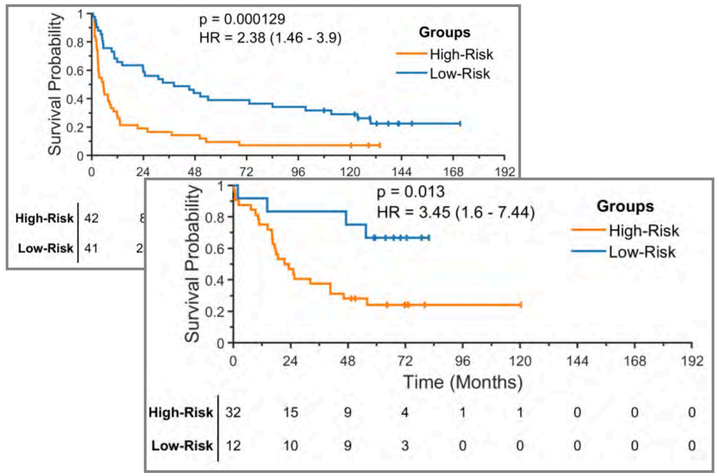
Nenning et al. 2023 ***Neuro. Onc. Adv.*** doi.org/10.1093/noajnl/vdad136

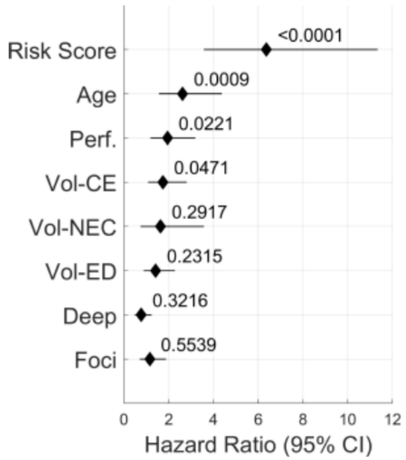
From prediction to target identification



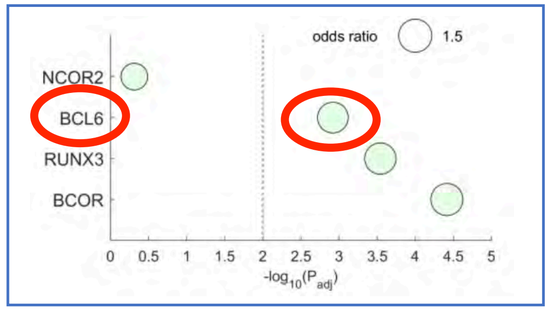




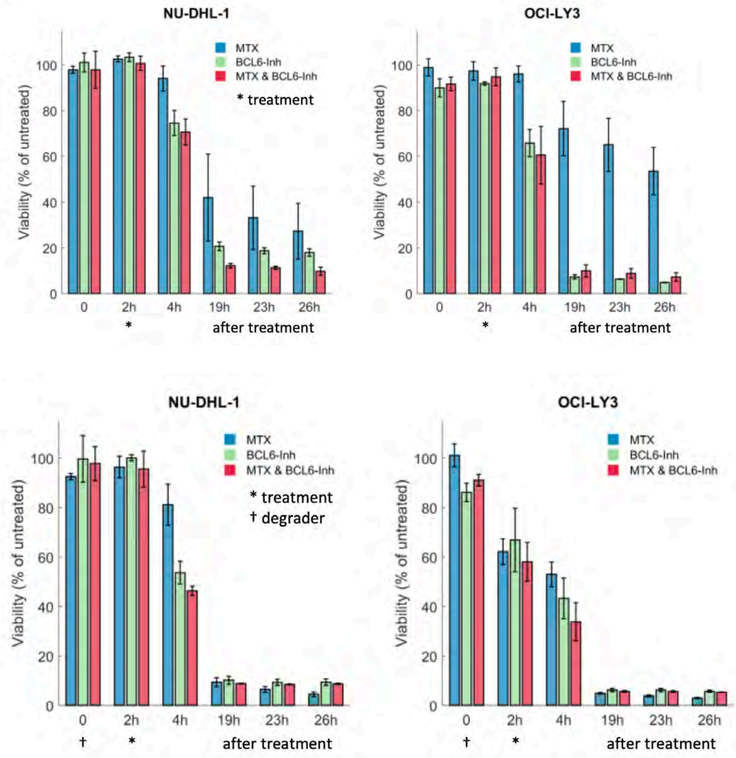




1. Predict outcome



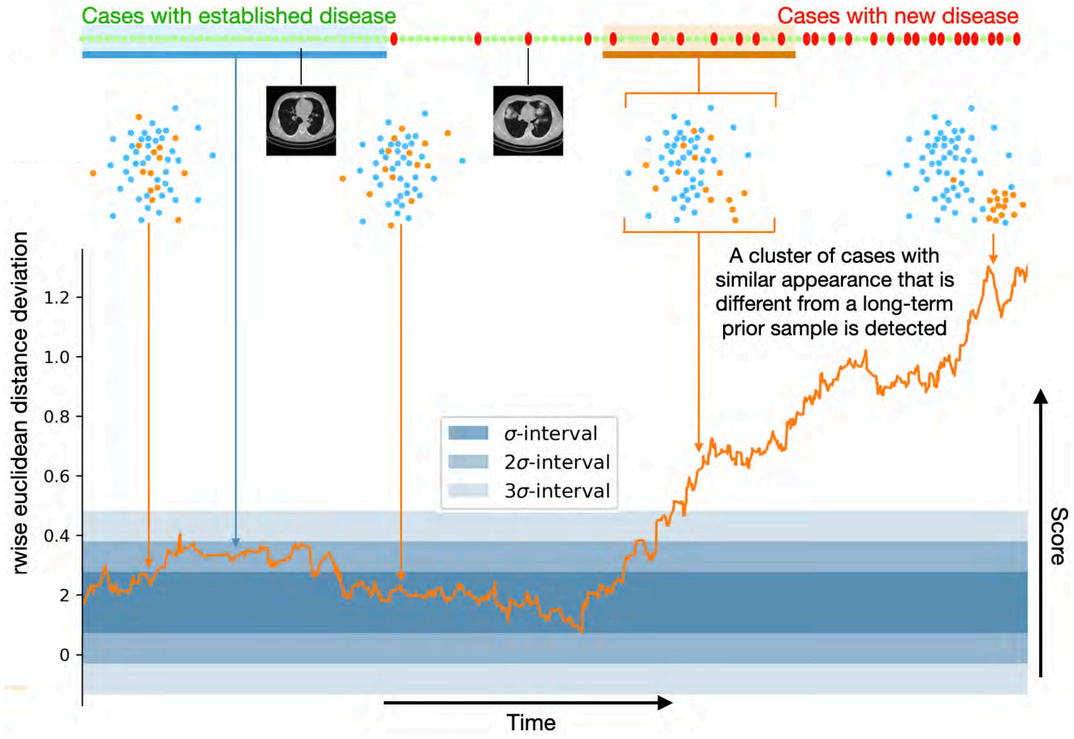
2. Identify target



3. Verify target in-vitro

Nenning et al. 2023 ***Neuro. Onc. Adv.*** doi.org/10.1093/noajnl/vdad136

Global surveillance for emerging diseases

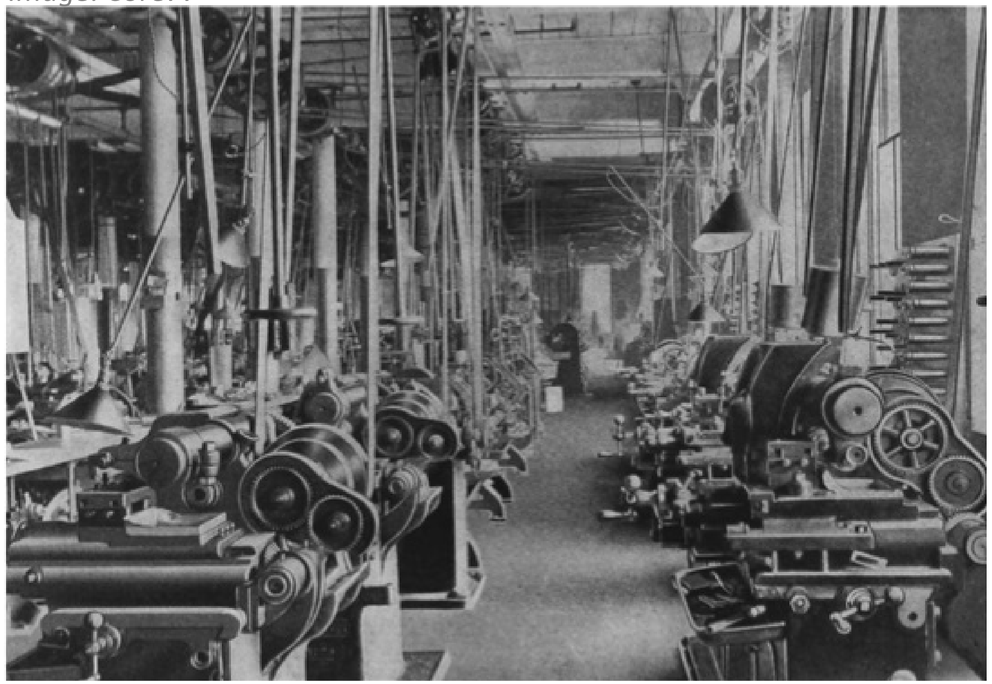


IAEA, WHO - ZODIAC Observatory

Straub et al. 2025 ***Eur. Radiol.*** doi.org/10.1007/s00330-024-11183-8 | Mitic et al. 2024 ***MLMI*** doi.org/10.1007/978-3-031-73290-4_14

Invention and adoption in industry: electricity

Image: Core77



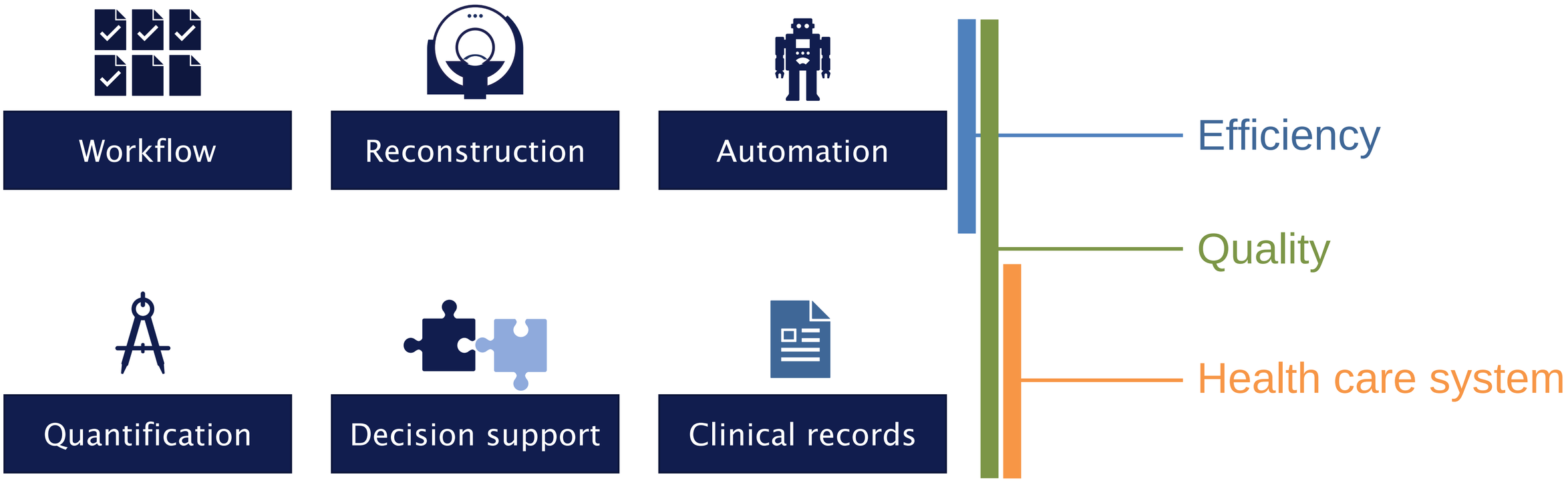
Factory driven by steam power
Organization: along axis of power transmission

~ 40 years

Image: Getty

Factory driven by electricity
Organization: along production line

Drivers of AI adoption in clinical routine

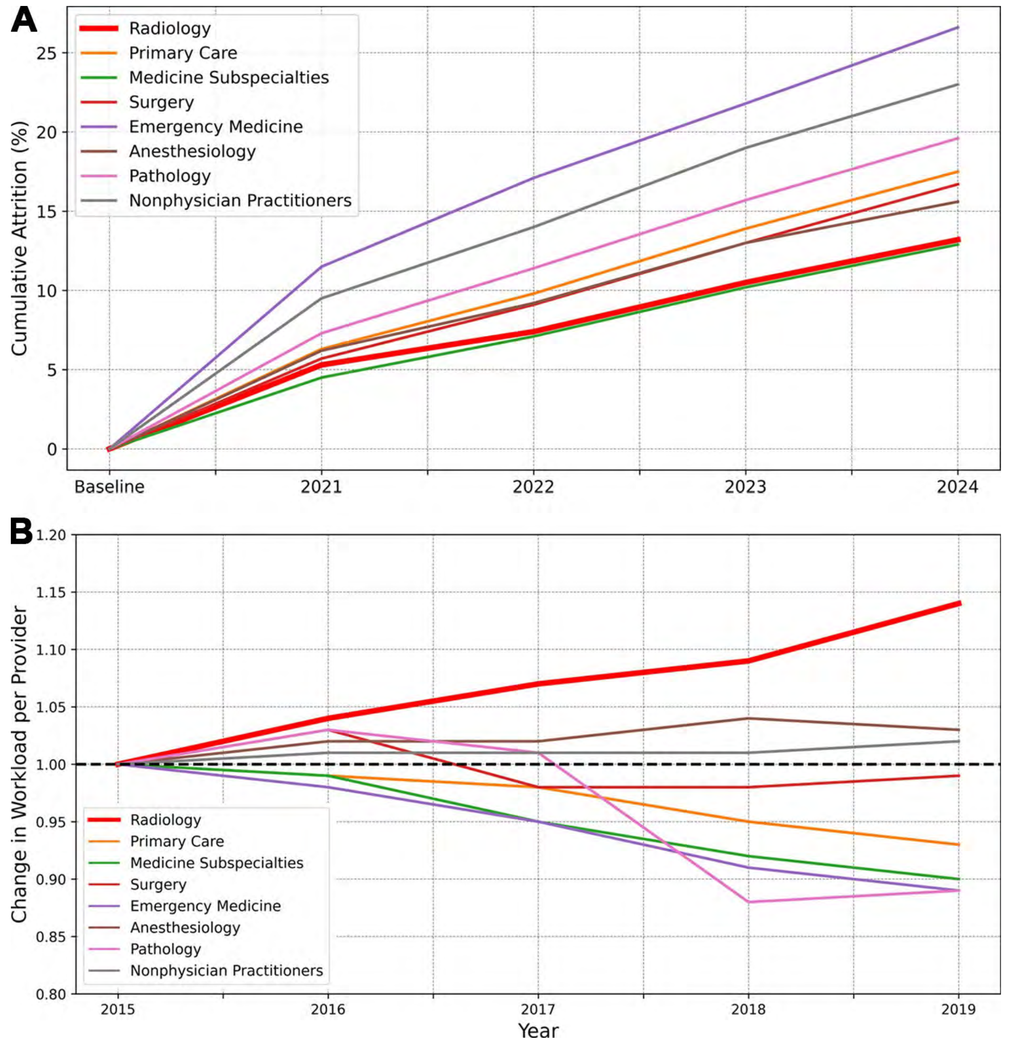


Röhrich et al. EURA 2022, Langs Radiology 2023, Hricak & Langs Radiology 2024

Rosentkrantz et al. Radiology 2024 | RSNA 2022 | McDonald et al. Ac Rad 2015

1. Efficiency - healthcare workforce gap

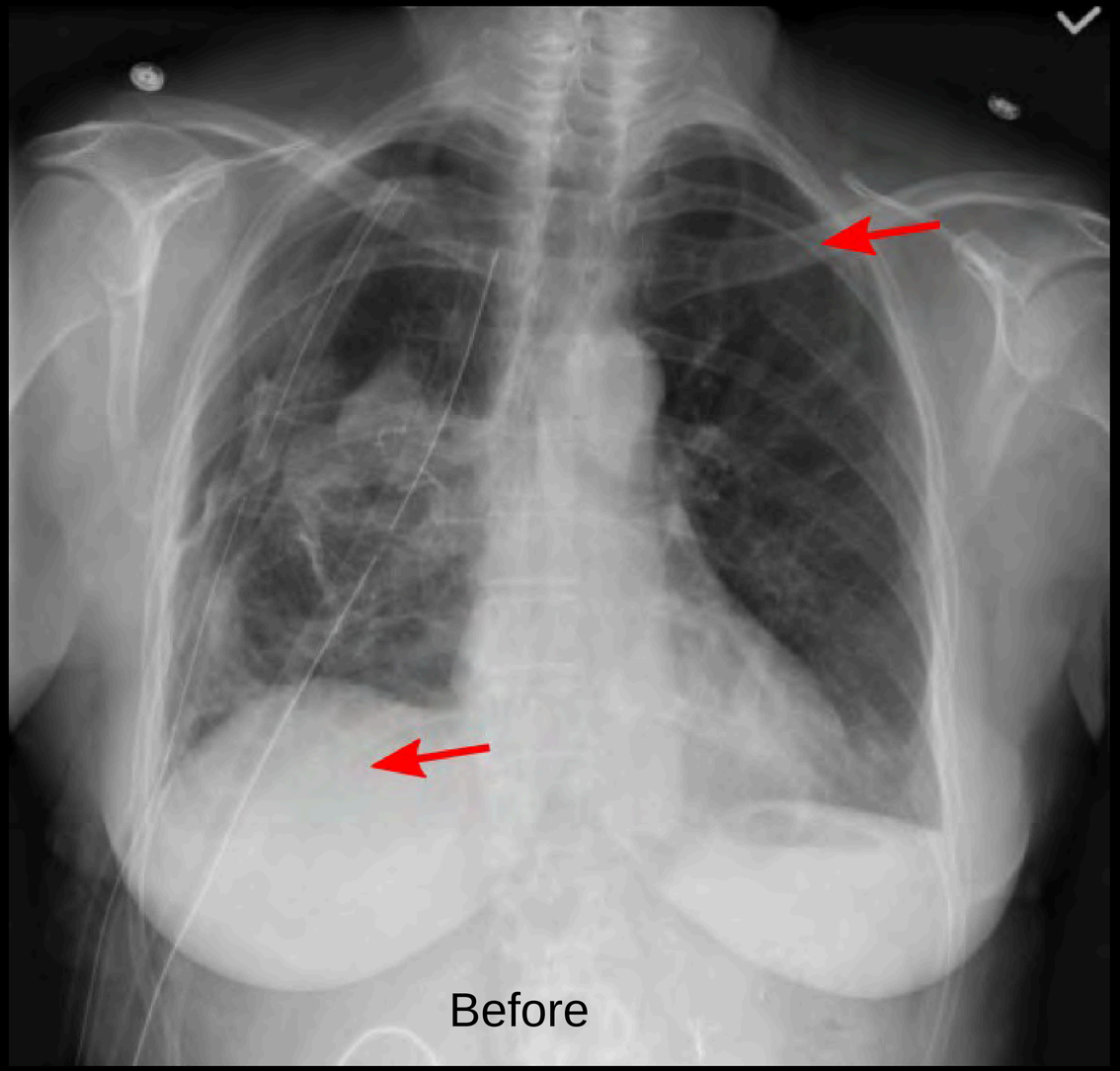
- Job postings *American College of Radiology* highest ever
- From 2010 to 2020:
  - DR trainees entering workforce increased by 2.5%
  - Adults over 65 increased by 34%
- Workload increase by 55-143%

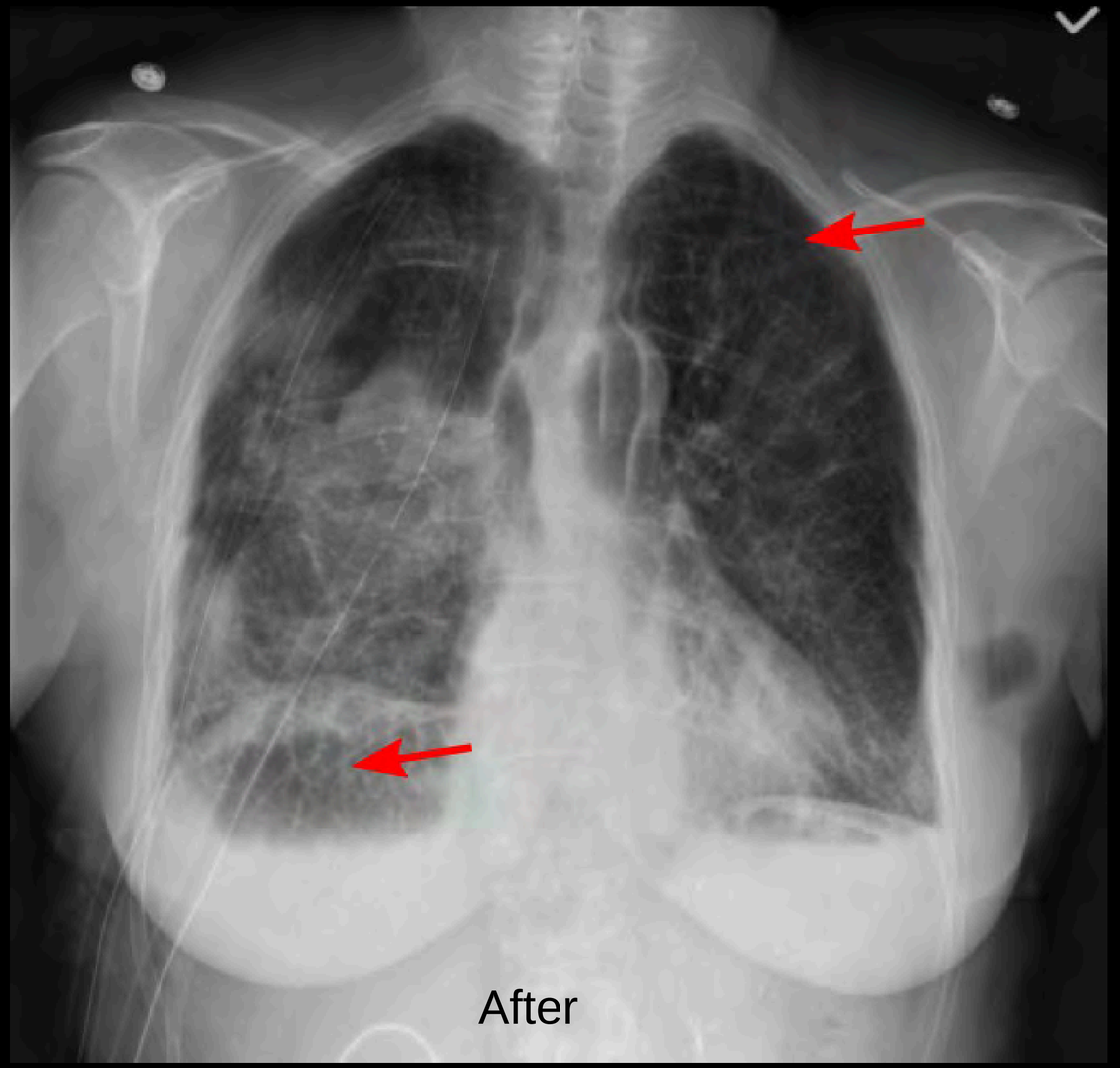


Workforce attrition in healthcare (US)

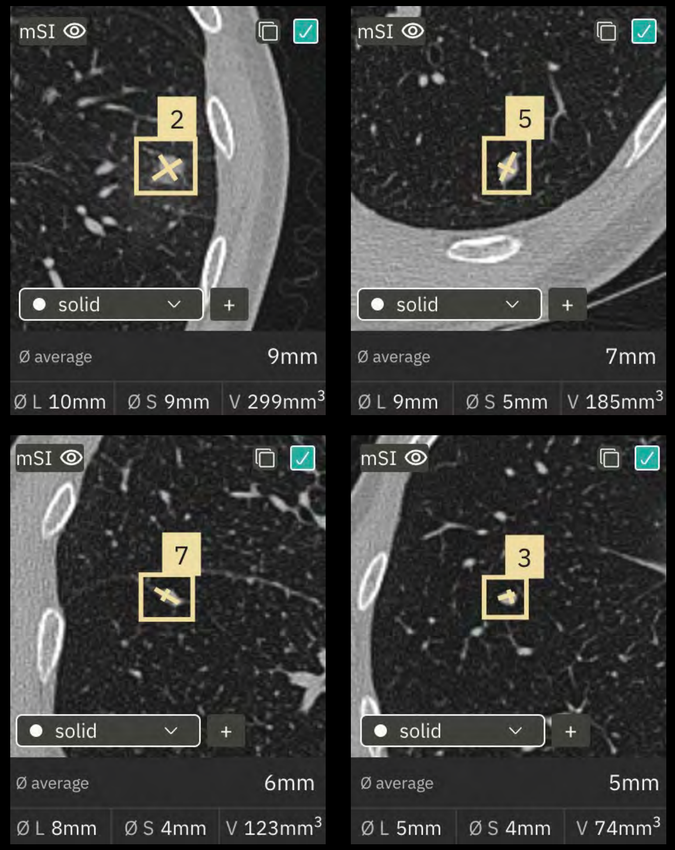
Hofmanninger et al. 2019

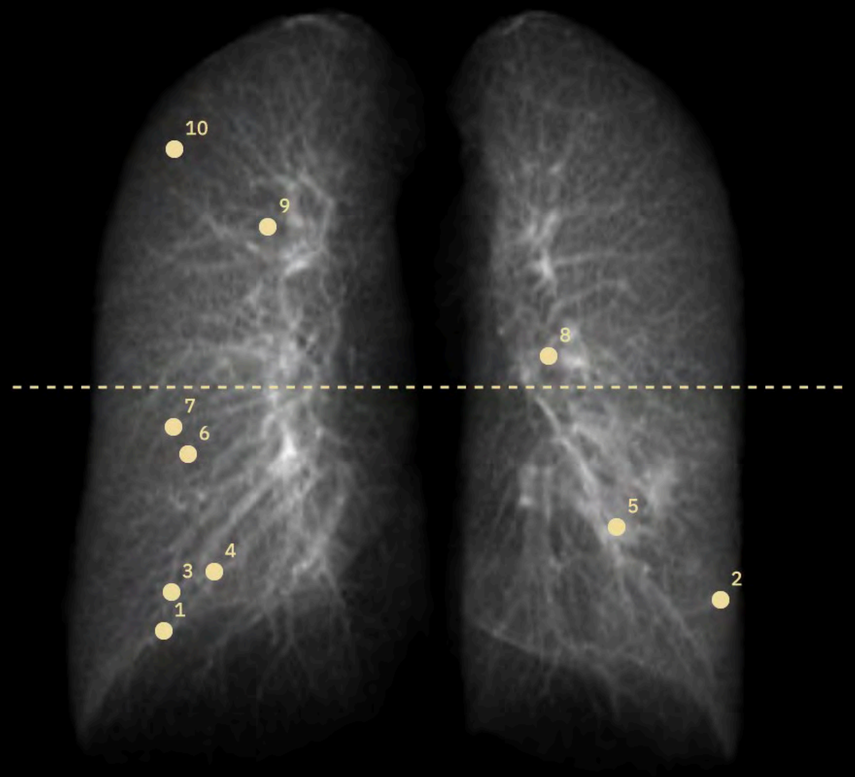
Enhancing images with AI

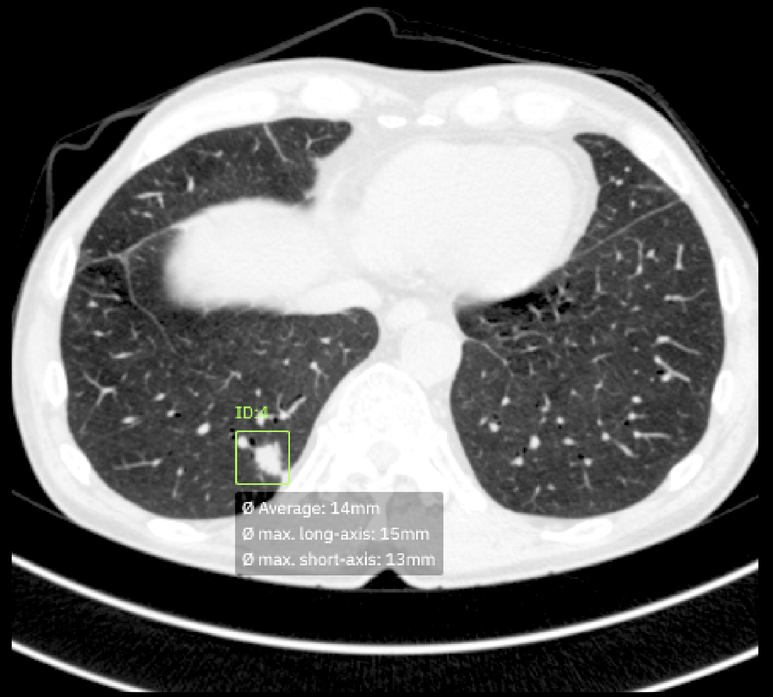




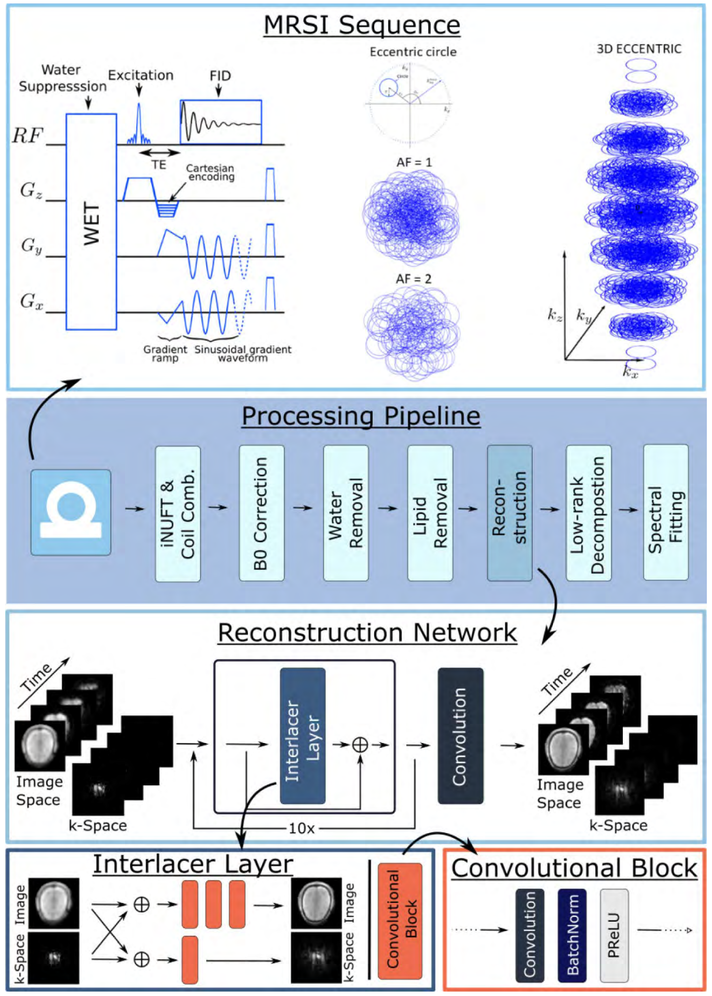
Automatic detection and risk prediction

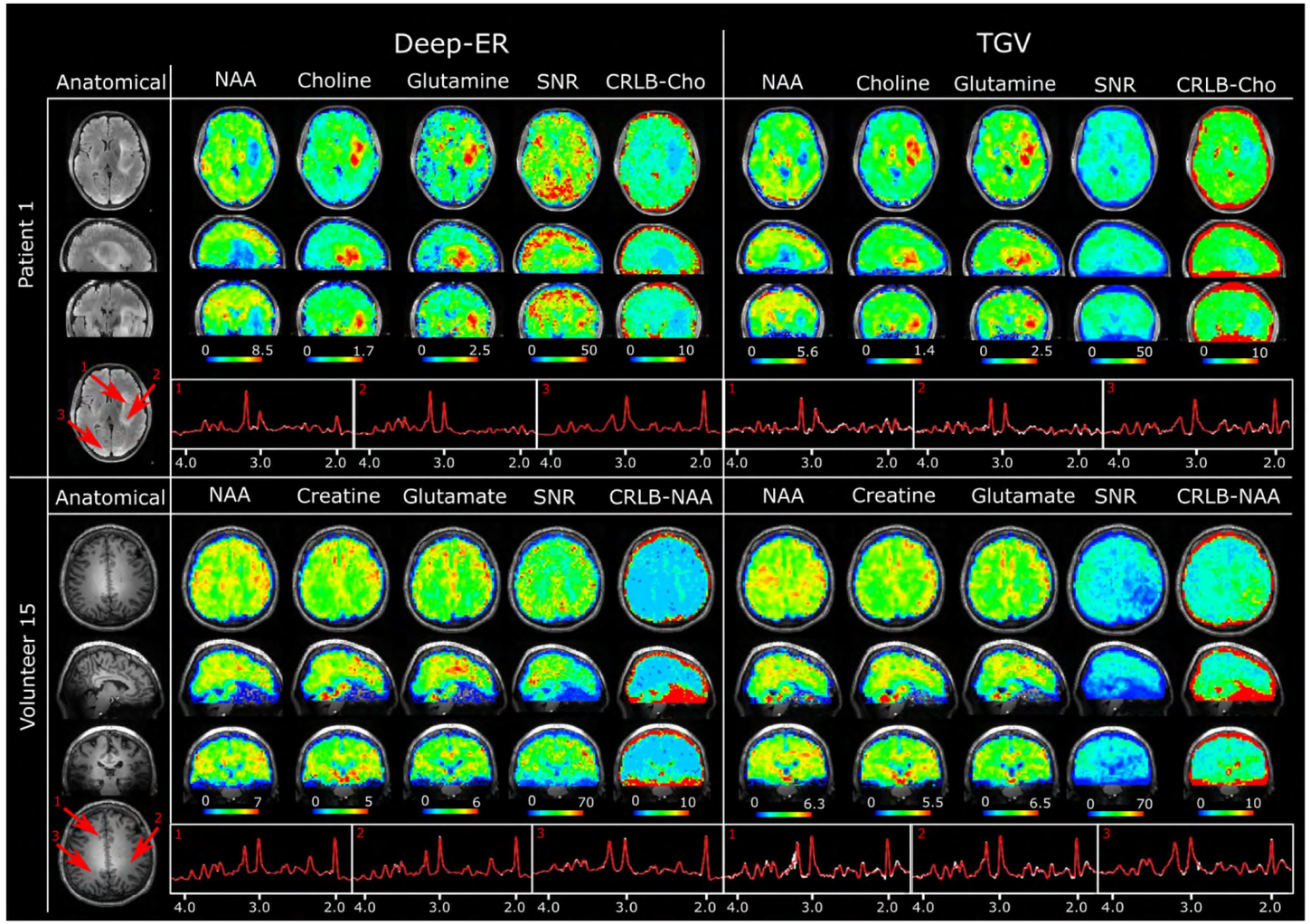






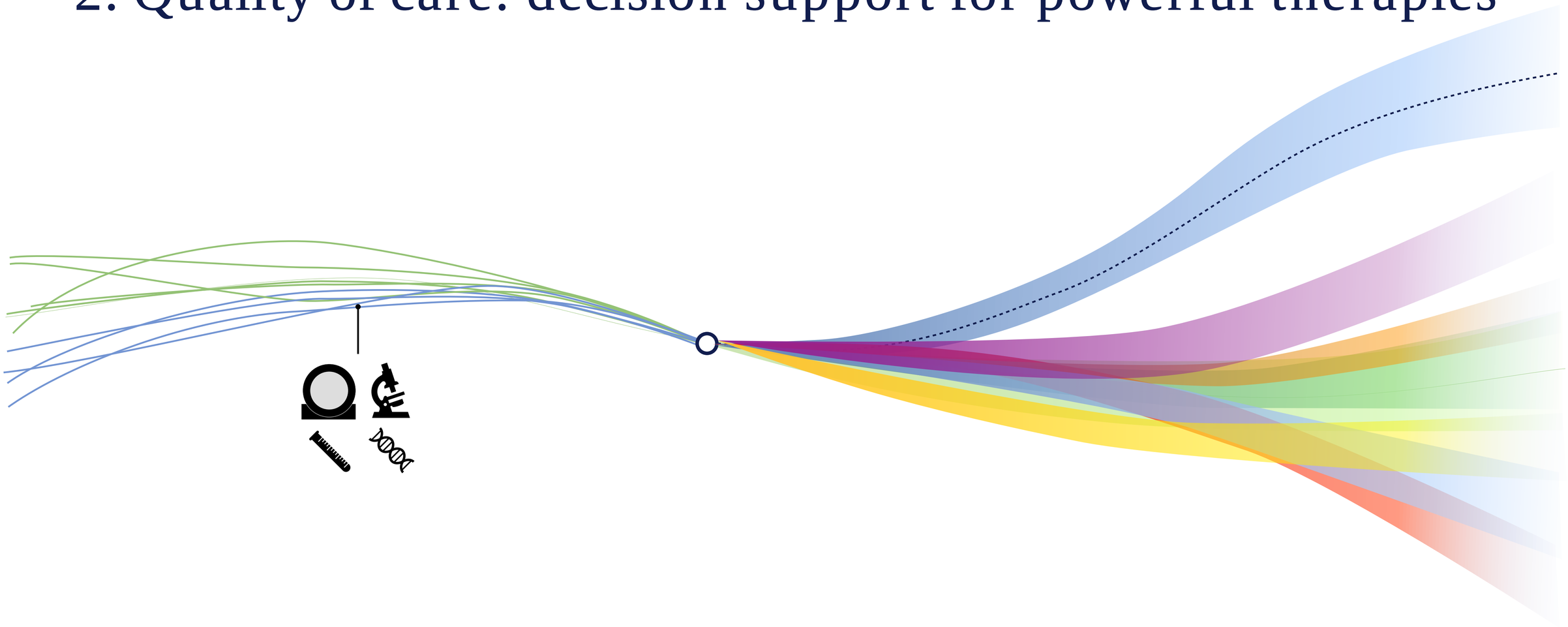
Reconstructing MR spectroscopy imaging



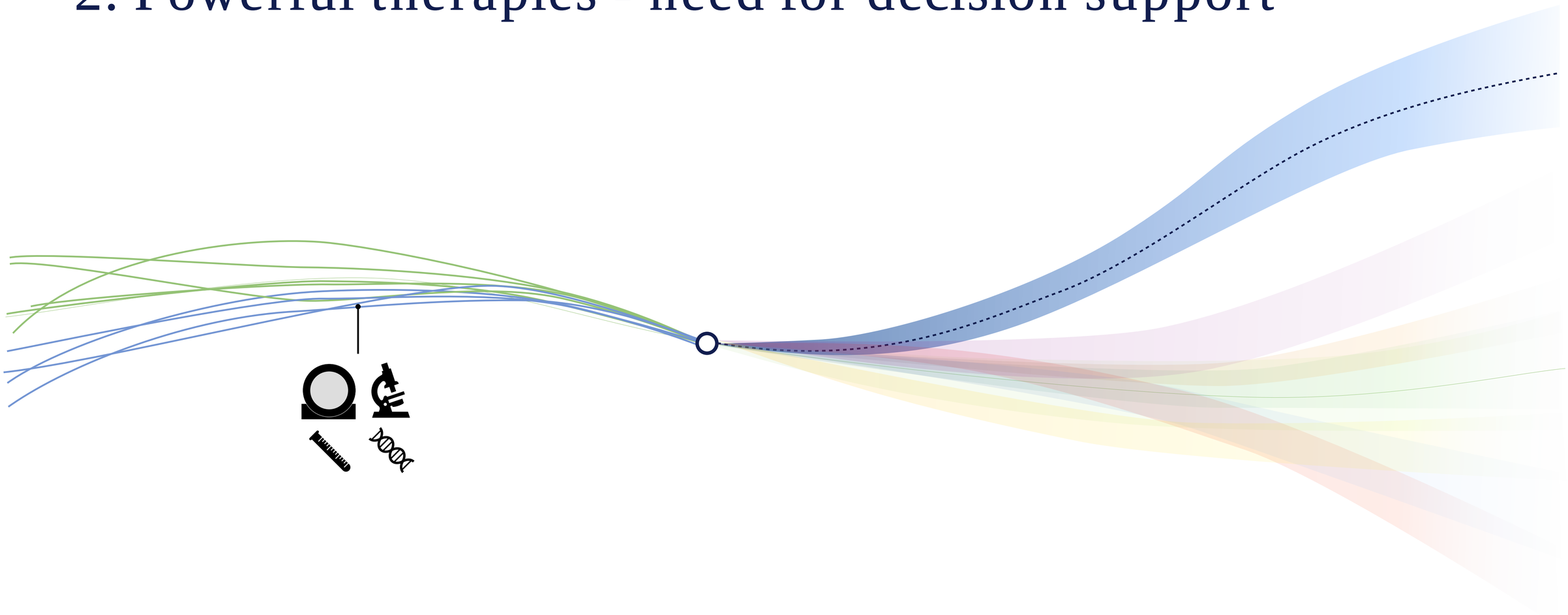


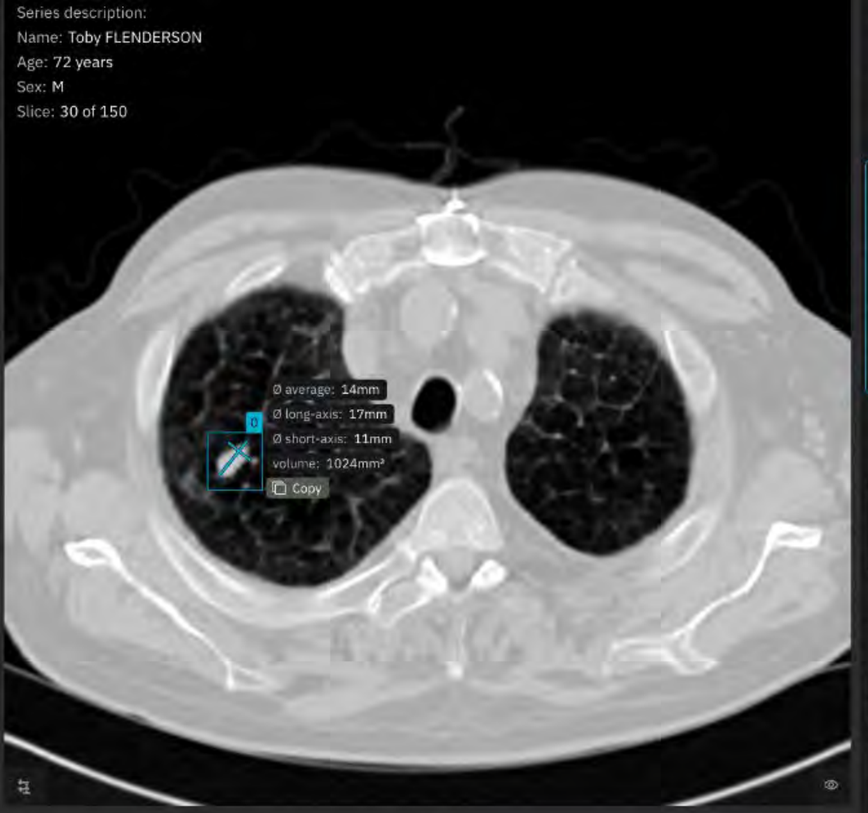
Weiser et al. 2025 https://doi.org/10.1016/j.neuroimage.2025.121045

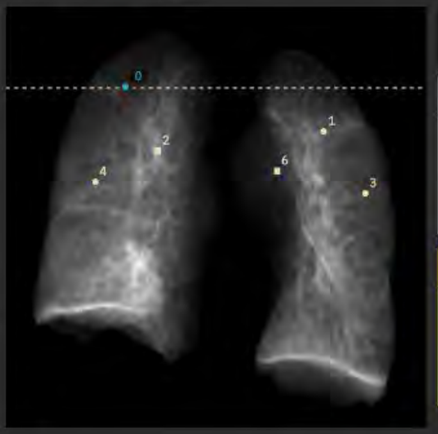
2. Quality of care: decision support for powerful therapies



2. Powerful therapies - need for decision support







Δ Cumulative volume	-576mm³
04.03.2016	
Detected nodules	5
Cumulative volume	2328mm³
04.04.2016	
Detected nodules	6
Cumulative volume	1752mm³

Guideline: Fleischner Guidelines
Sort by: volume
Max. long: 4mm – 30mm

	07.10.2014	04.03.2016	04.04.2016
Detected nodules	2	5	6
Cumulative volume	2691 mm³	2328 mm³	1752 mm³
Δ	-53% / -139d	-18% / -726d	-25% / -76d
Nodule	21.04.2015	19.11.2015	04.03.2016 / 04.04.2016
Volume	-	85 mm³	474 mm³	1024 mm³
Average	-	5 mm	10 mm	14 mm
Max. Long	-	5 mm	13 mm	17 mm
Max. Short	-	4 mm	6 mm	11 mm
Time to Double	-	-	43 d	28 d
Nodule	solid	solid		

Volume	329 mm³	309 mm³	275 mm³
Average	9 mm	10 mm	9 mm
Max. Long	12 mm	12 mm	10 mm
Max. Short	6 mm	8 mm	7 mm
Time to Double	-	-1170 d	-188 d
Nodule	solid	solid	part-solid

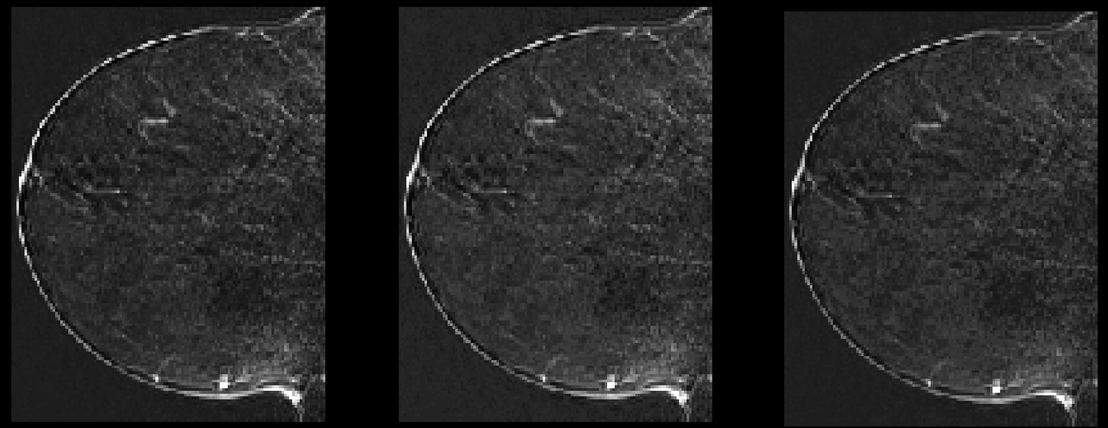
Volume	2390 mm³	1472 mm³	1295 mm³	176 mm³
Average	21 mm	18 mm	19 mm	9 mm
Max. Long	23 mm	19 mm	21 mm	11 mm
Max. Short	20 mm	16 mm	17 mm	6 mm
Time to Double	-123 d	-303 d	-574 d	-11 d
Nodule	solid	solid	solid	

Volume	233 mm³	221 mm³	170 mm³	137 mm³
Average	7 mm	7 mm	6 mm	6 mm
Max. Long	8 mm	8 mm	7 mm	7 mm
Max. Short	5 mm	5 mm	5 mm	6 mm
Time to Double	-	-2709 d	-284 d	-97 d
Nodule	solid	solid	solid	

Volume	67 mm³	91 mm³	80 mm³	96 mm³
Average	5 mm	5 mm	5 mm	5 mm
Max. Long	5 mm	5 mm	5 mm	5 mm
Max. Short	4 mm	4 mm	4 mm	5 mm
Time to Double	-318 d	484 d	-535 d	116 d
Nodule	solid	solid	solid	

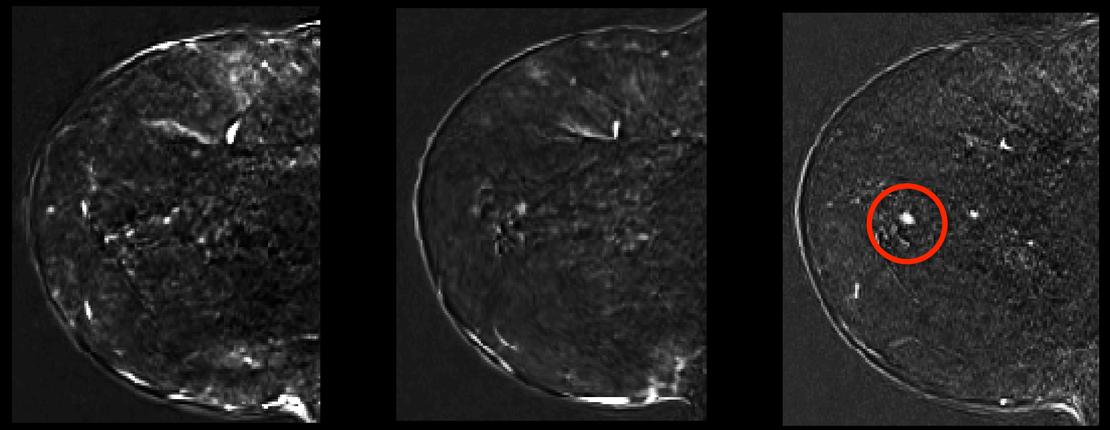
Prevention in breast cancer: early disease signatures

Subject 1



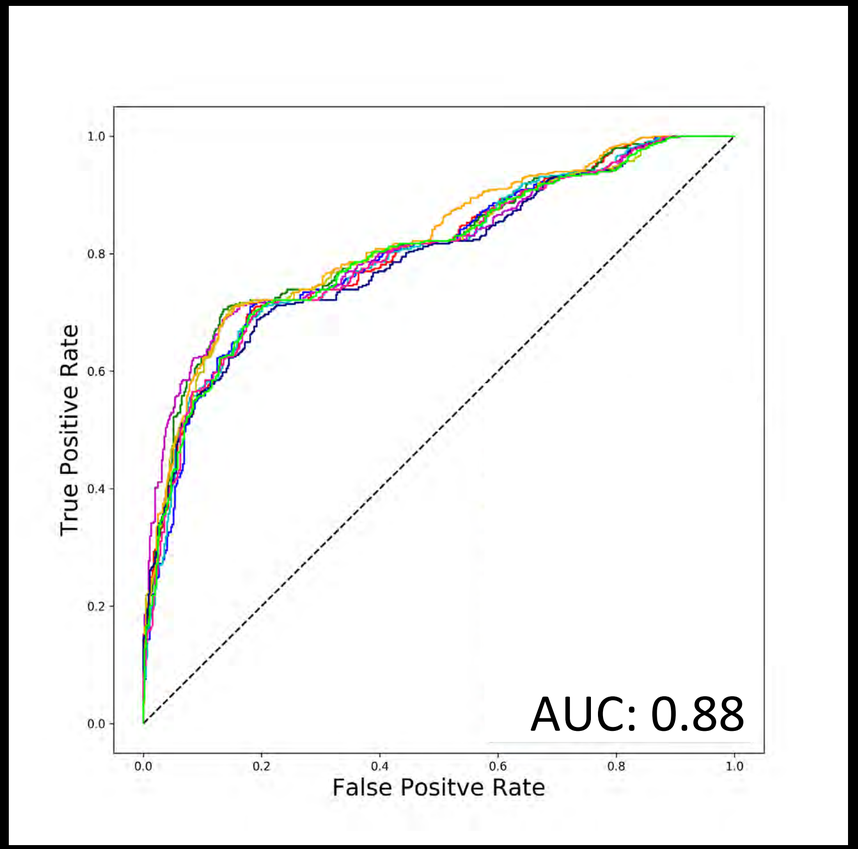
No lesion

Subject 2



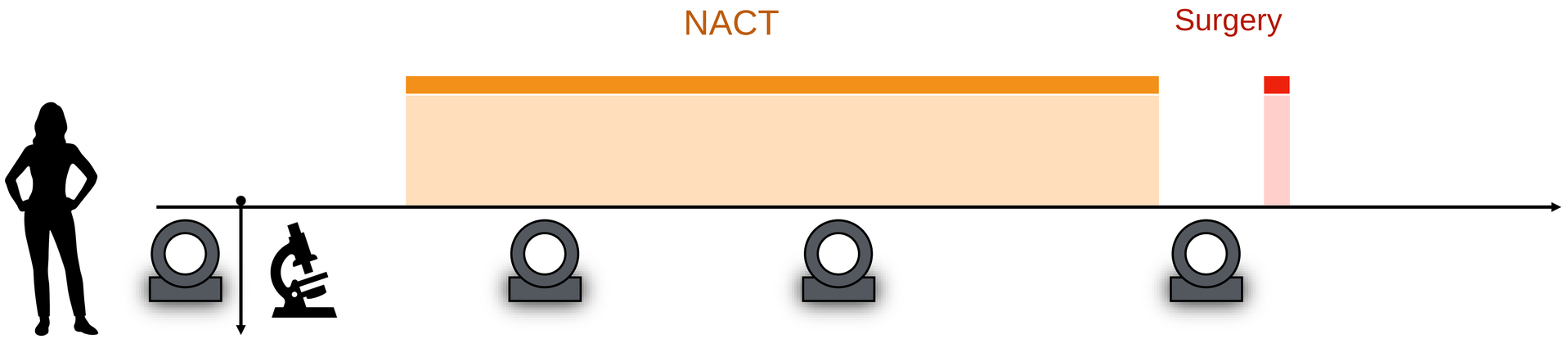
Lesion

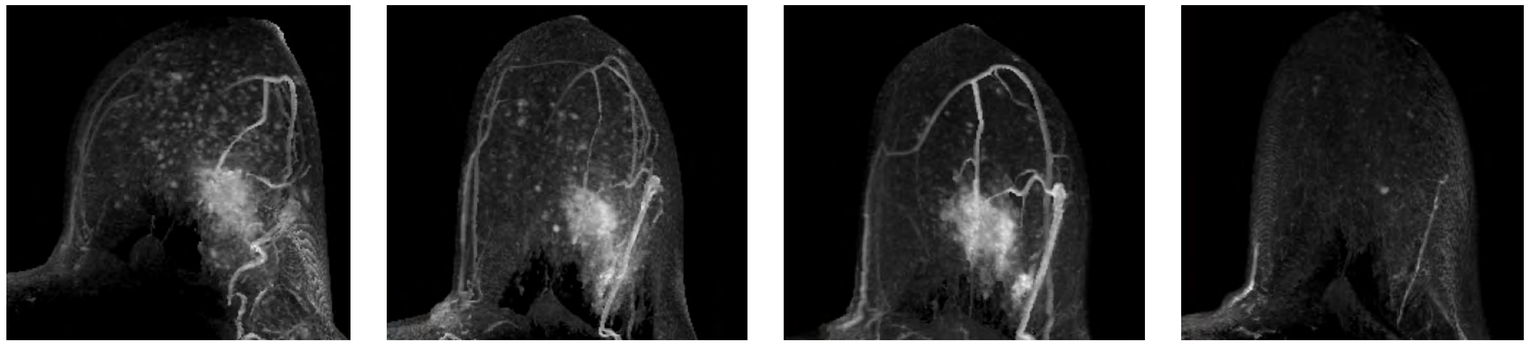
Previous visit Now Next visit



Burger, Helbich, Langs et al EURE 2023

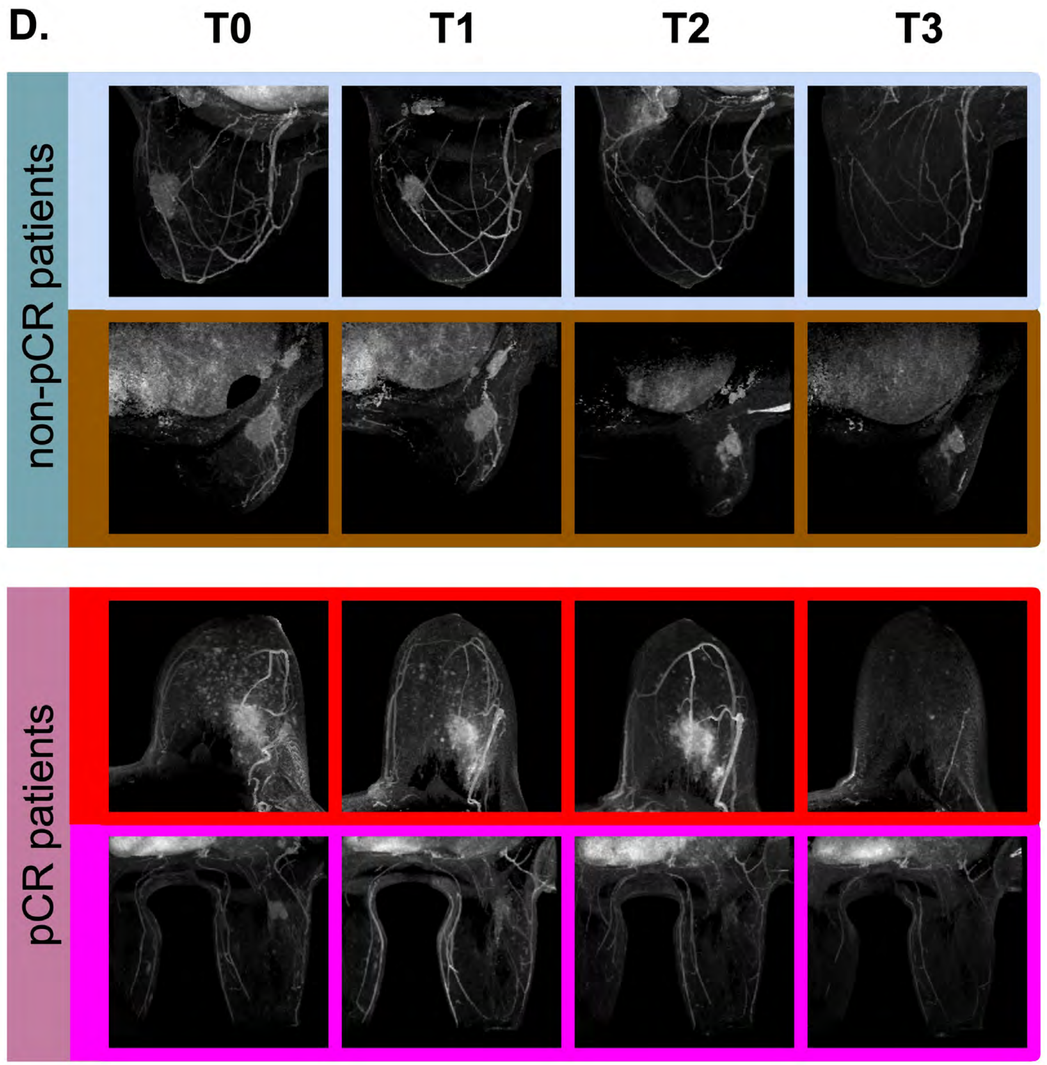
Predicting response to Neoadjuvant Chemotherapy in BC

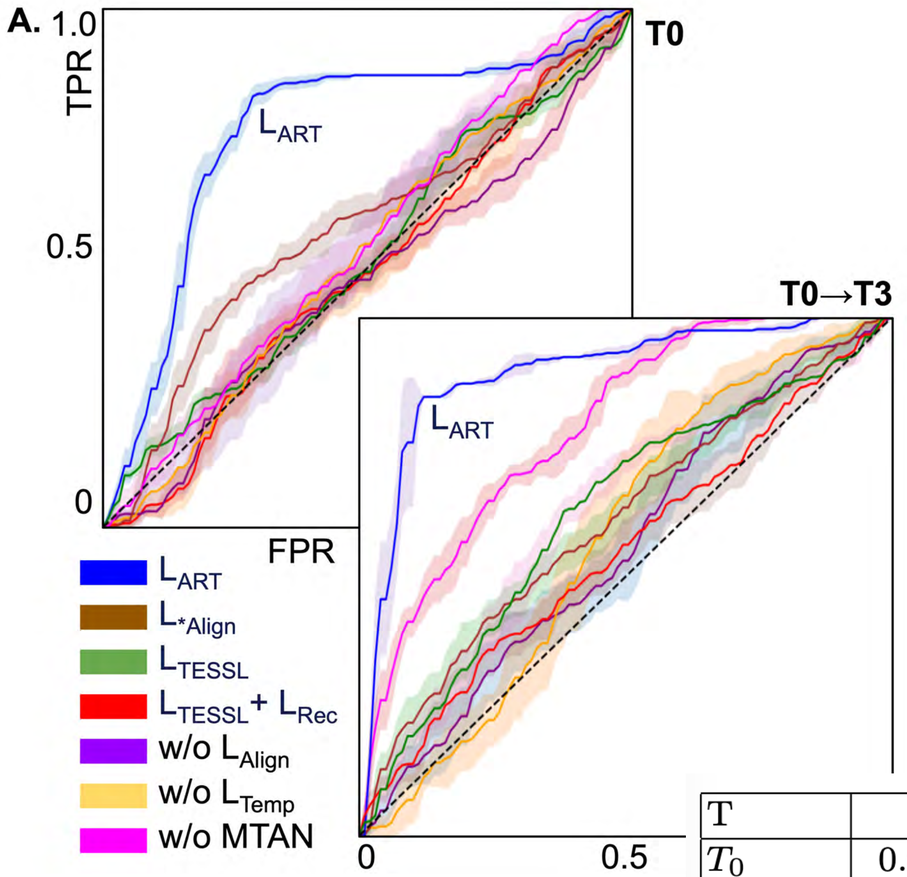




WWTF - PREDICTOME *Janickova et al. MICCAI 2025* *https://arxiv.org/abs/2509.14872*

Predicting response to Neoadjuvant Chemotherapy in BC

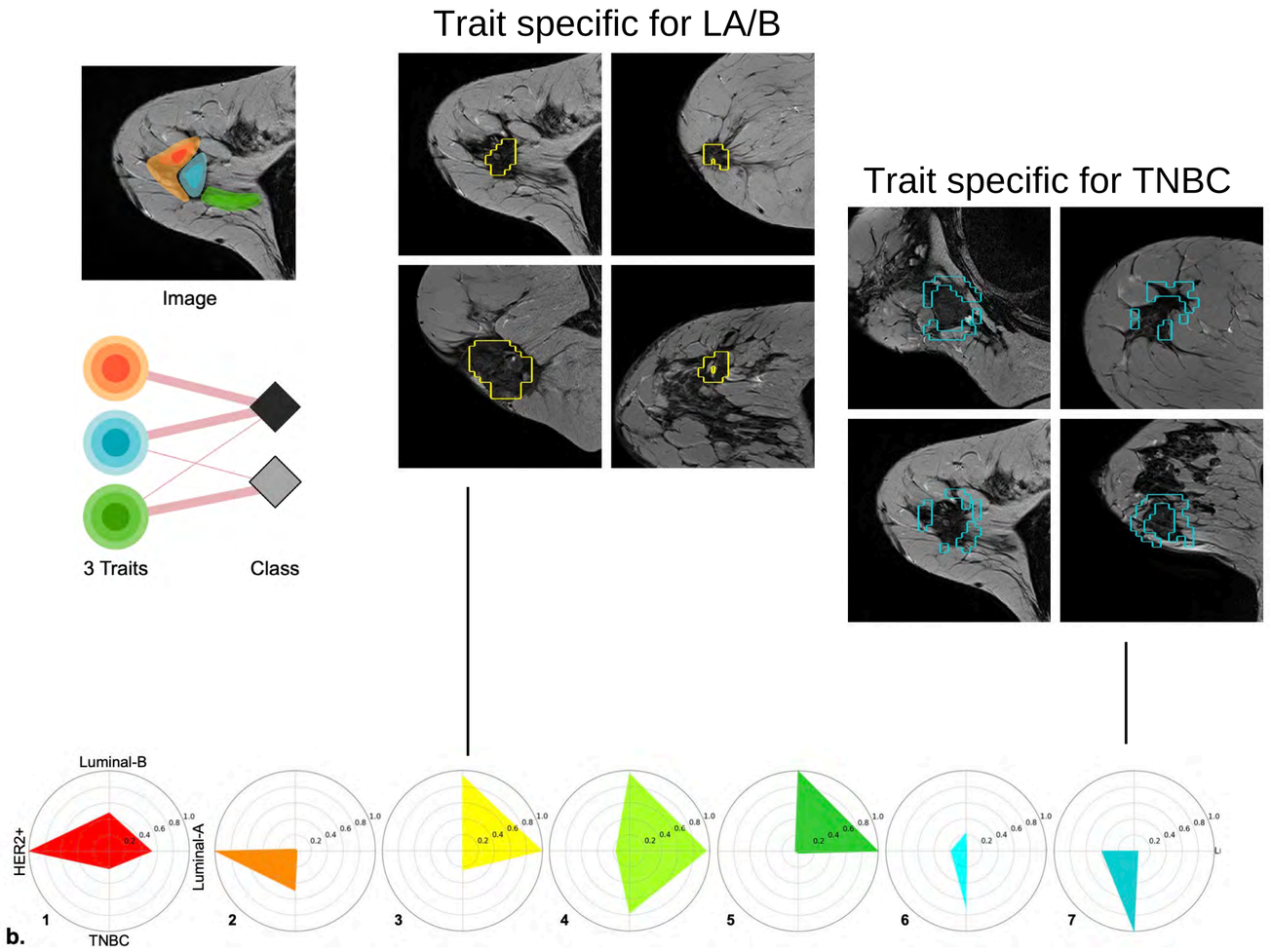


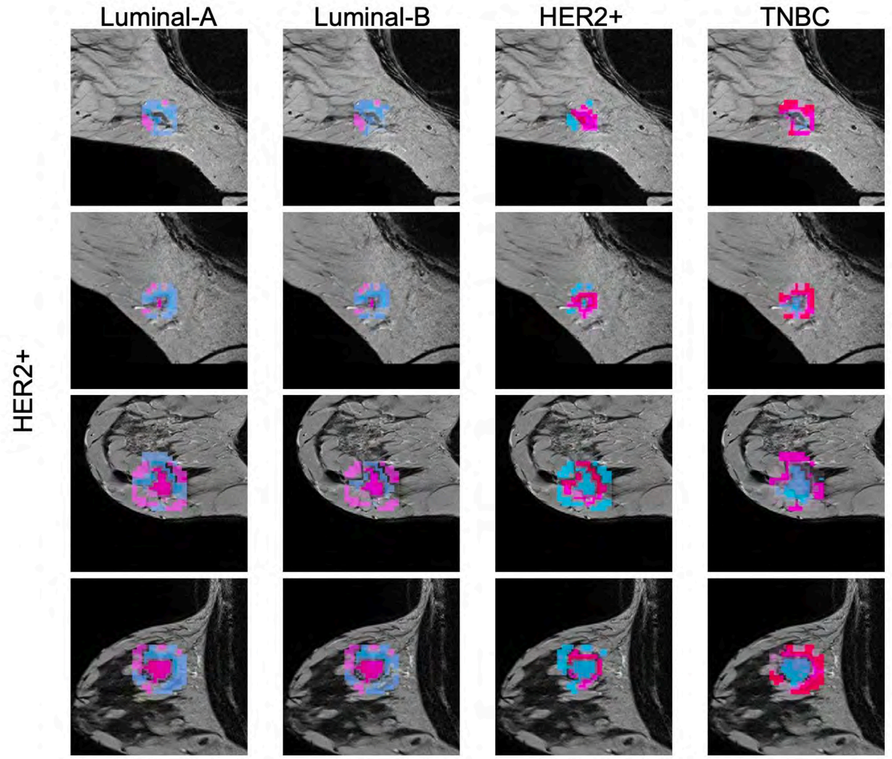


T	PPV	NPV
T_0	0.603±.02	0.852±.01
$T_0 + T_1$	0.721±.02	0.883±.02
$T_0 \rightarrow T_3$	**0.772±.02**	**0.920±.01**

WWTF - PREDICTOME *Janickova et al. MICCAI 2025* *https://arxiv.org/abs/2509.14872*

Link imaging traits to molecular tumor sub-types

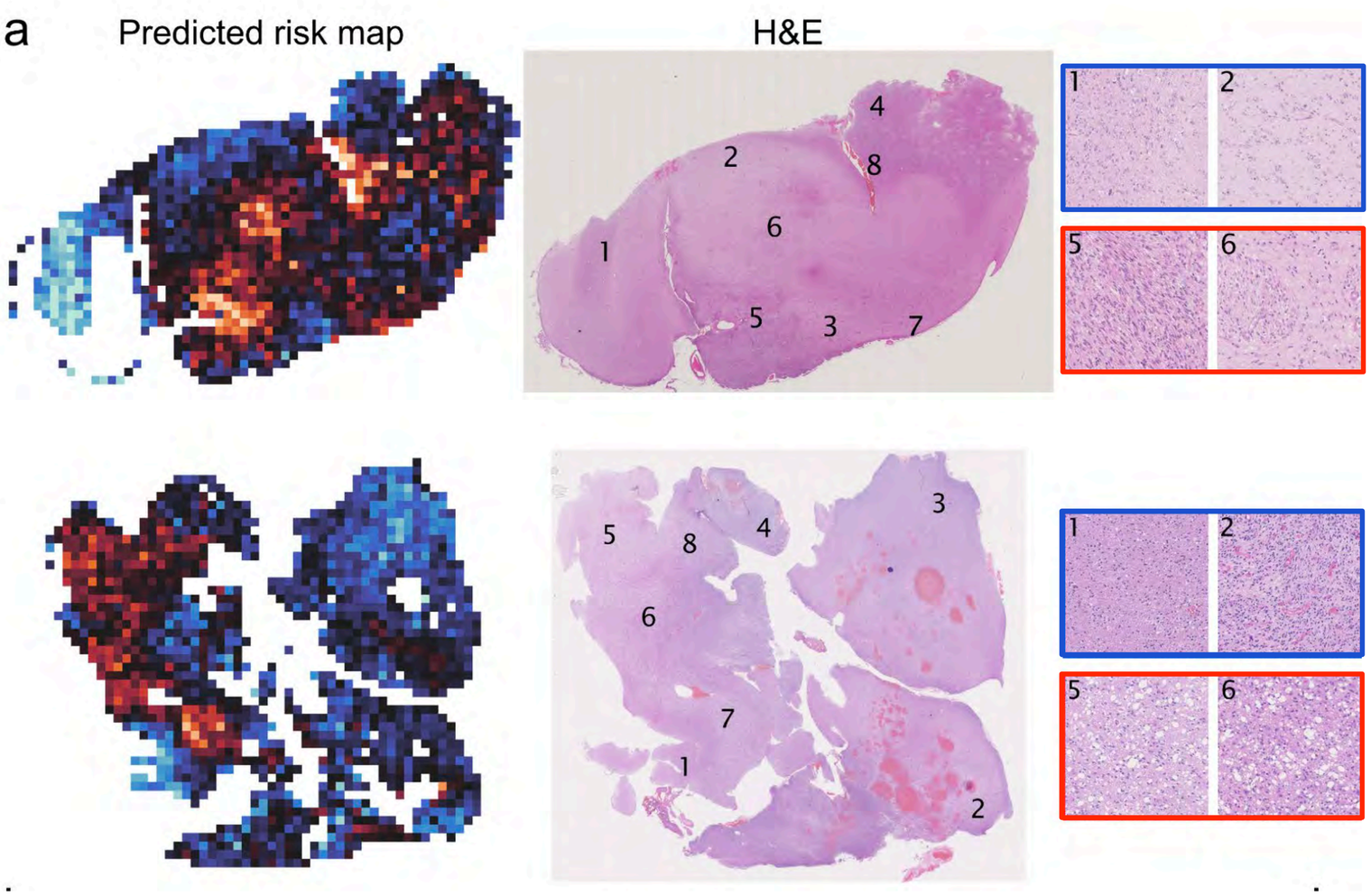


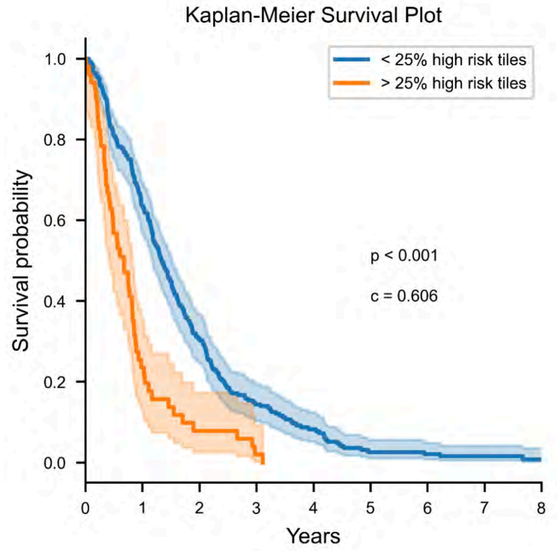


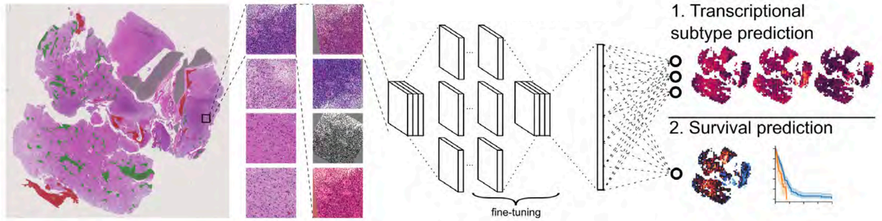
Profiling a tumor: traits consistent with sub-type / with other sub-types

Funded by **WWTF** www.cir.meduniwien.ac.at/predictome

Linking imaging data to molecular information and risk





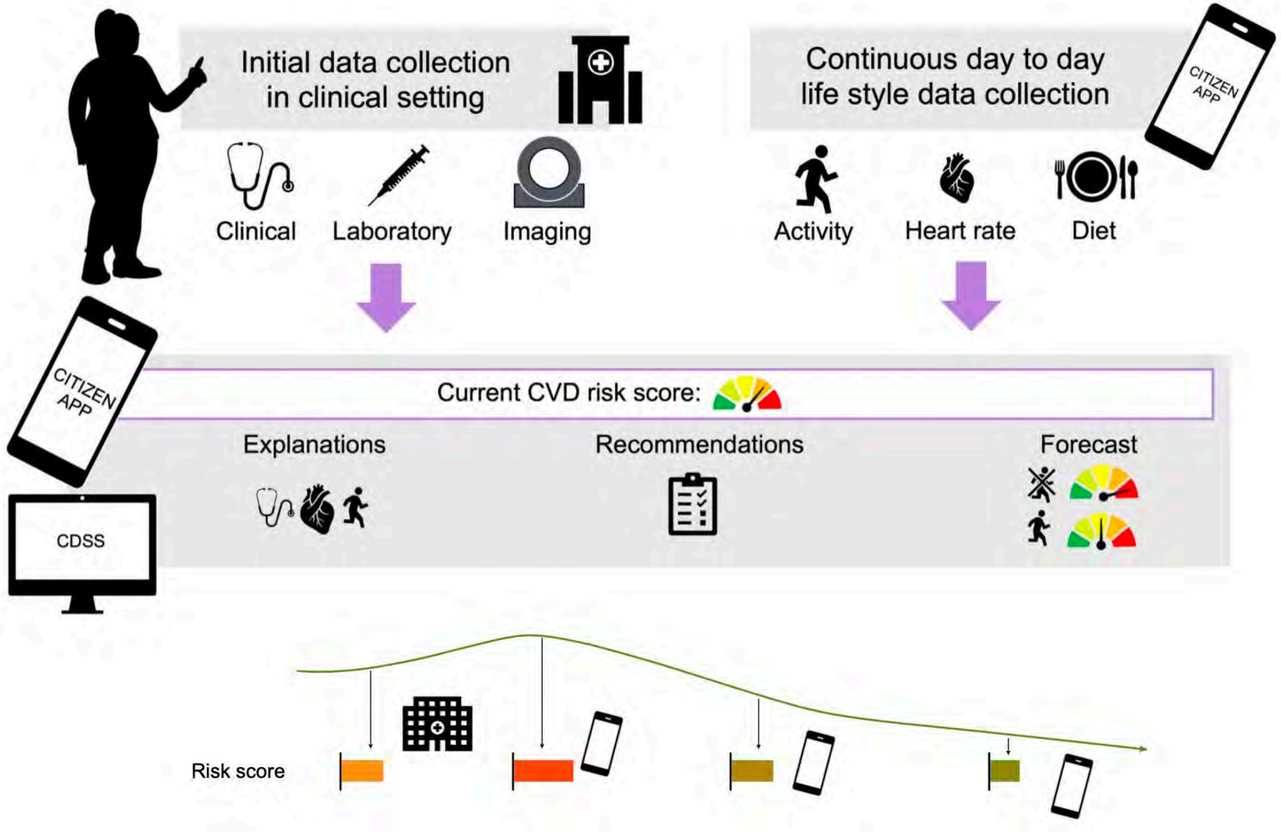


Thomas Rötzer GigaScience 2024

Outside the hospital: informing patients

AI for the Prediction of Obesity-Related Vascular Diseases

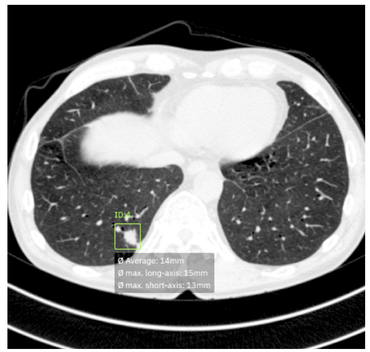
Integrating the influence of diet and lifestyle in real-time monitoring

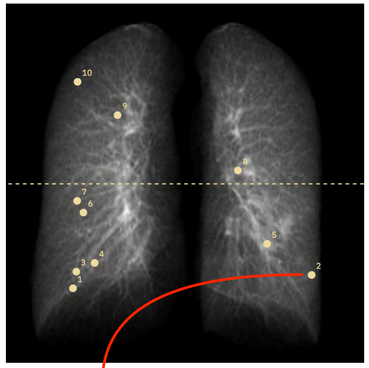


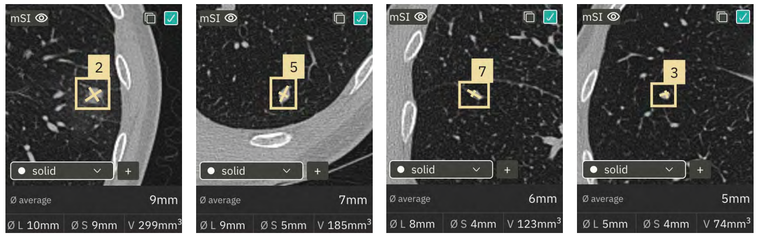
Funded by the European Union

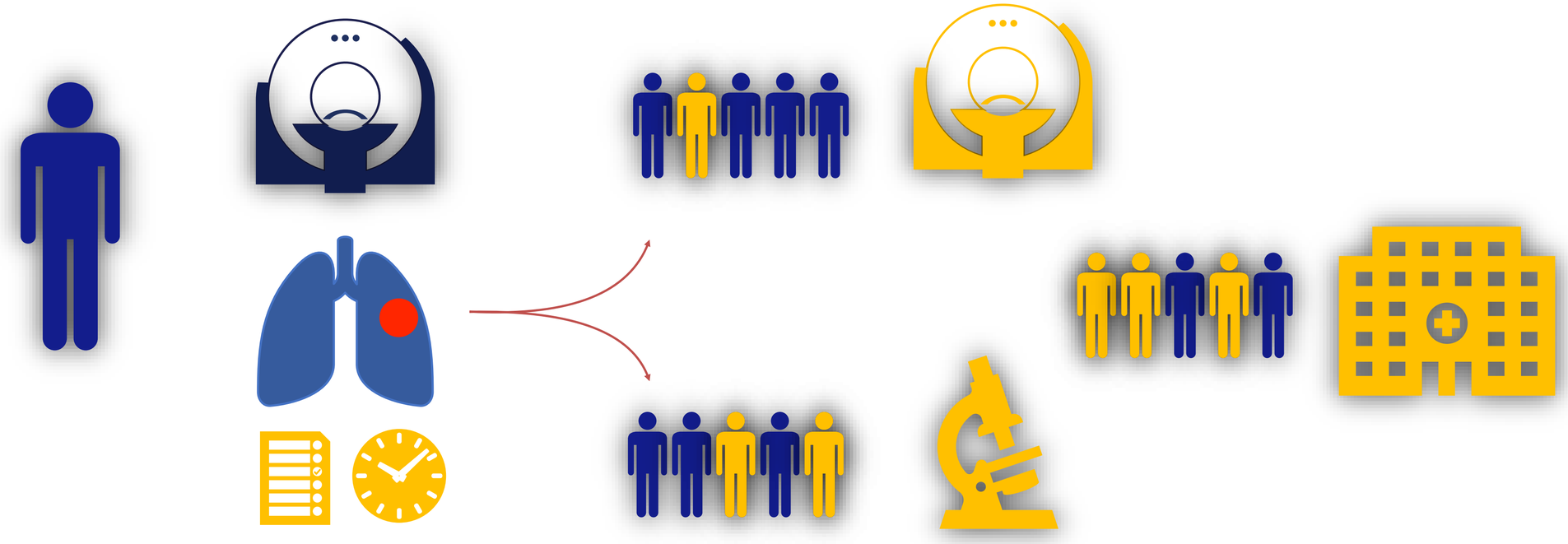
www.ai-pod.eu

3. Patient pathways - actionable information

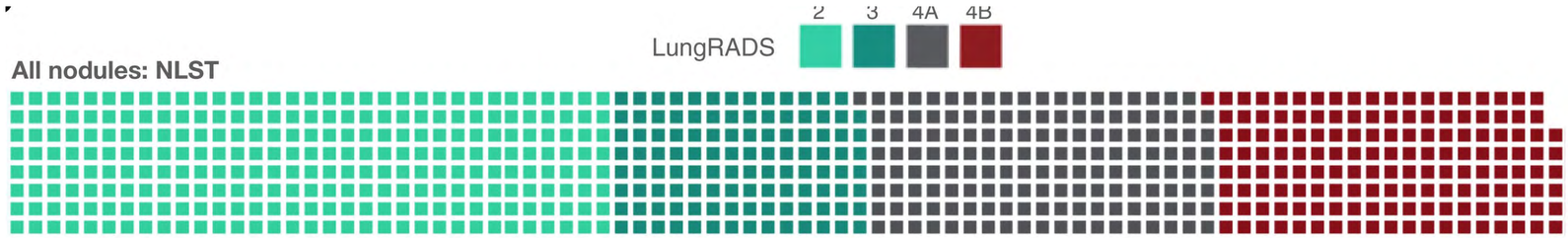








Impact of malignancy prediction to augment guidelines



Follow-up
Biopsy
No action

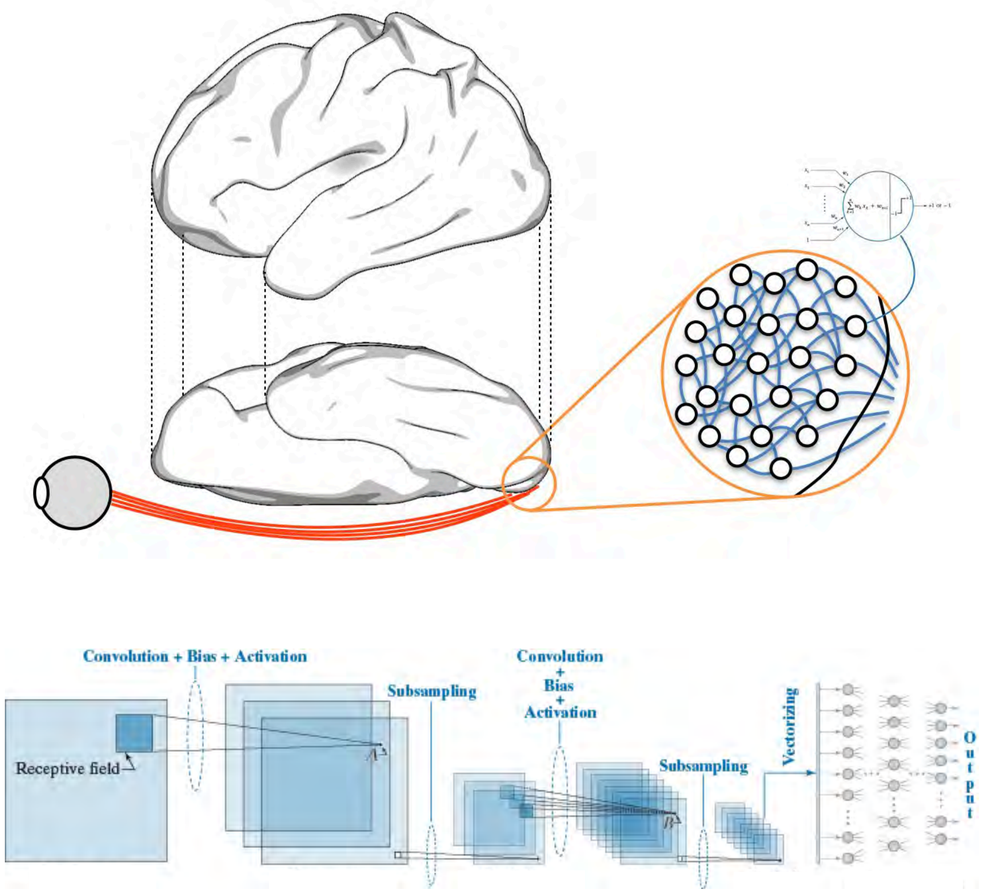
Impact on downstream management
Augmenting guidelines with AI scoring mSI: eliminate diagnostic delay of interval scan in 33-45%, and reducing false positives

Adams et al. JACR 2022

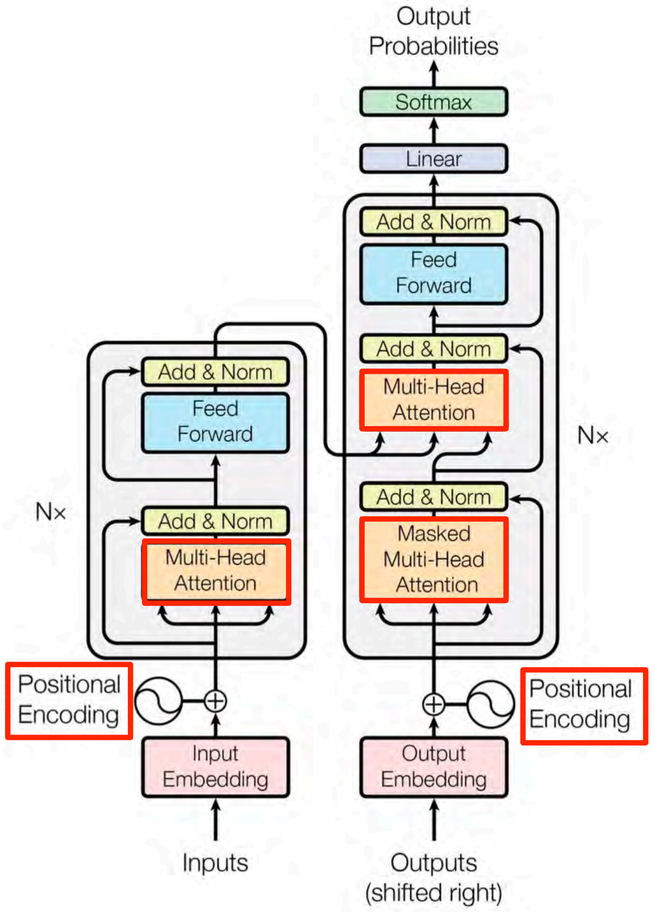
Agentic AI

Deeper integration, increased robustness & unknowns

Transformers: learning to translate large sequences



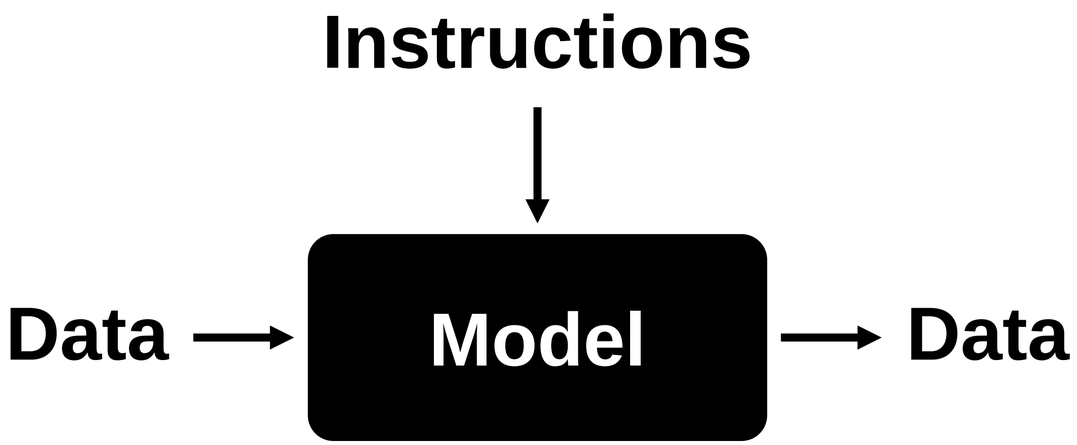
Convolutional neural networks

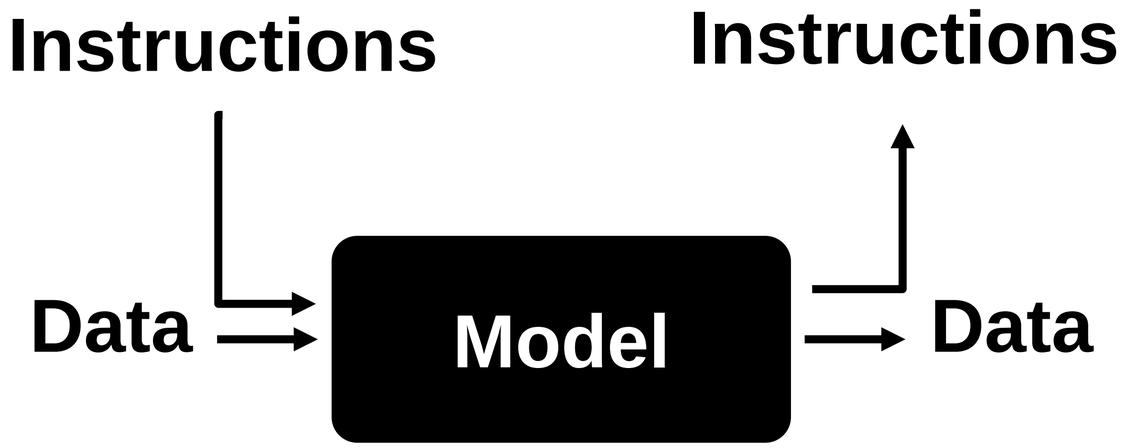


Transformers

Ashish Vaswani et al. *Attention is all you need* 2017 NeurIPS - 198.960 citations

Agents - what's new?





AI Agents in Healthcare

- Multi-agent systems for healthcare (MASH) deliver workflows
- Natural language communication, planning, coordination, and reasoning
- Enabled by robust input/output in the form of language

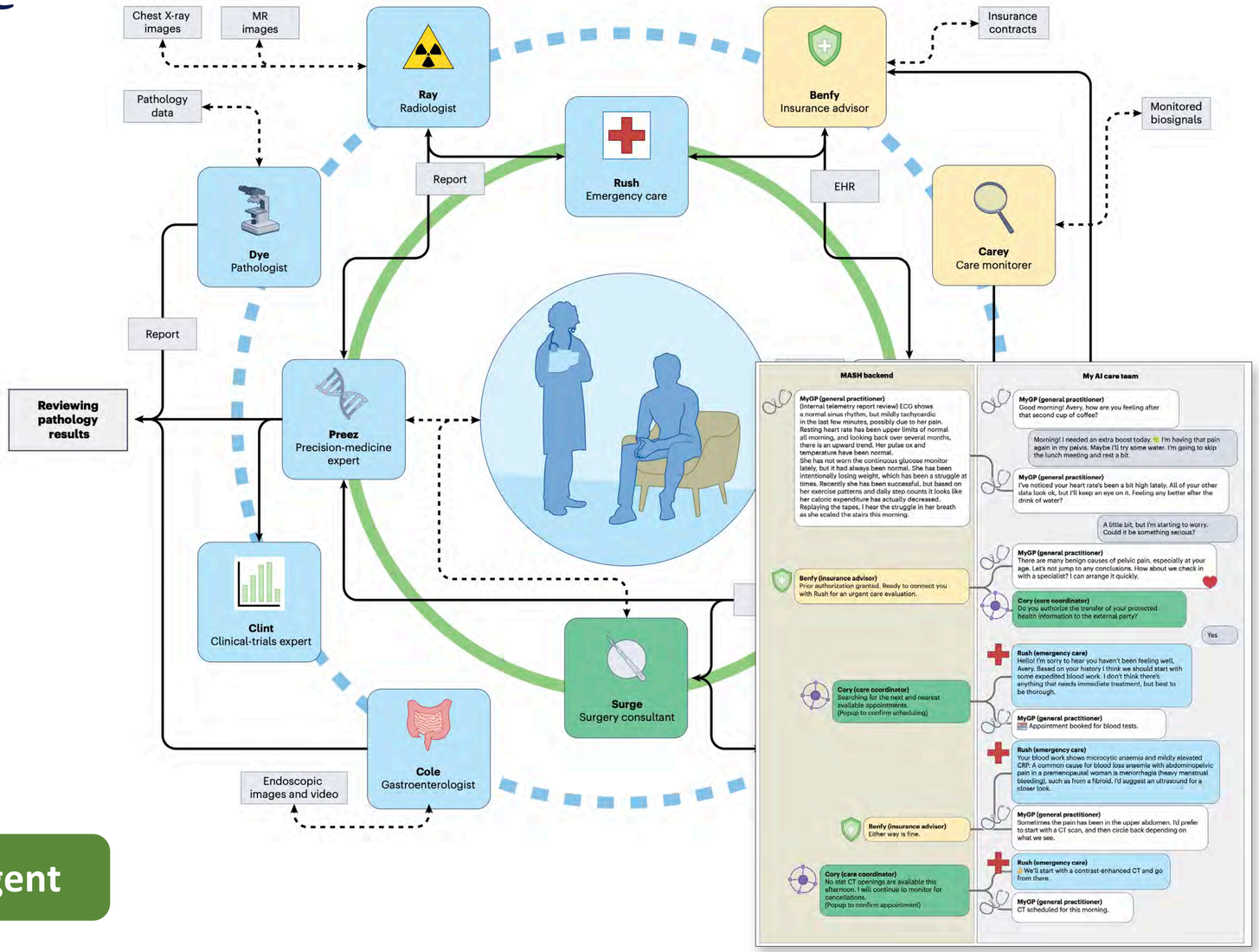
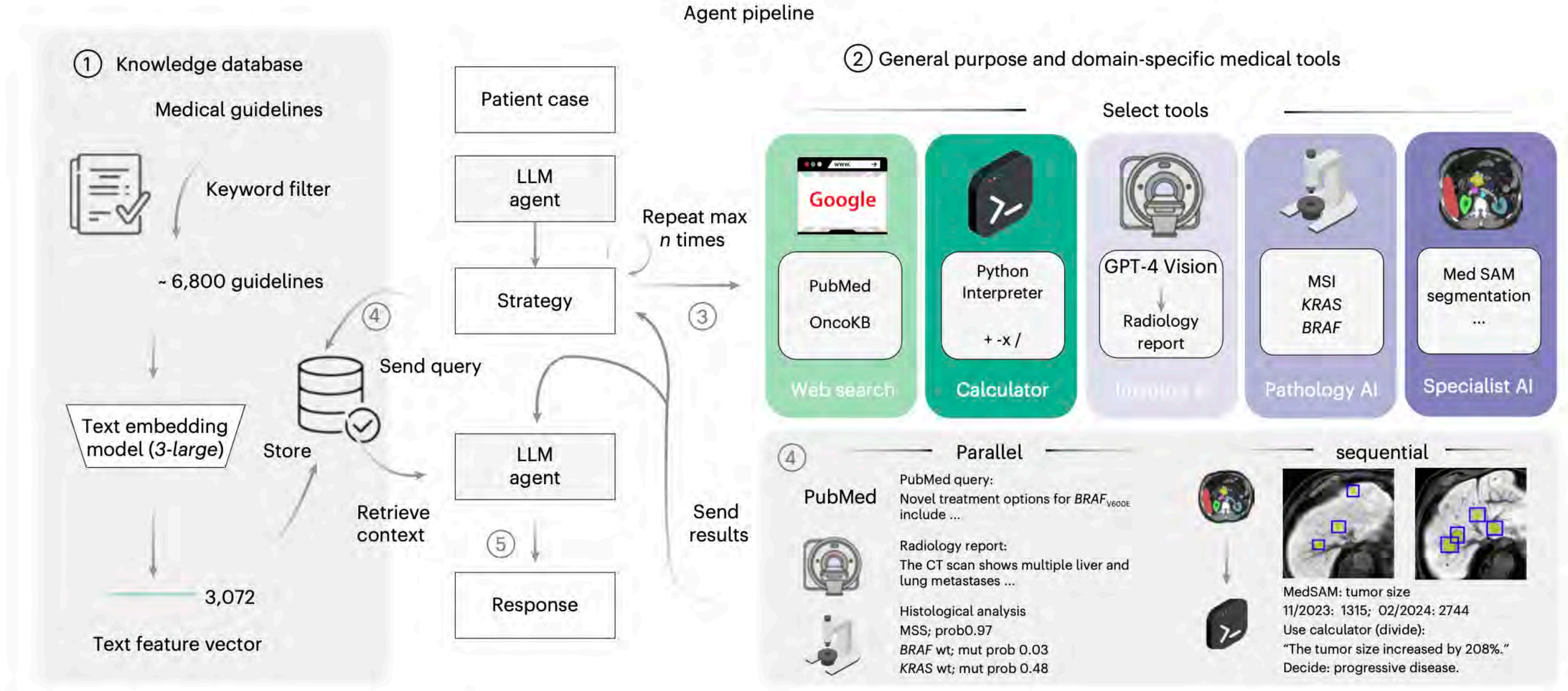


Figure from Moritz et al. April 2025 ***Nature*** doi.org/10.1038/s41551-025-01363-2

Agents: LLMs give instructions to other LLMs

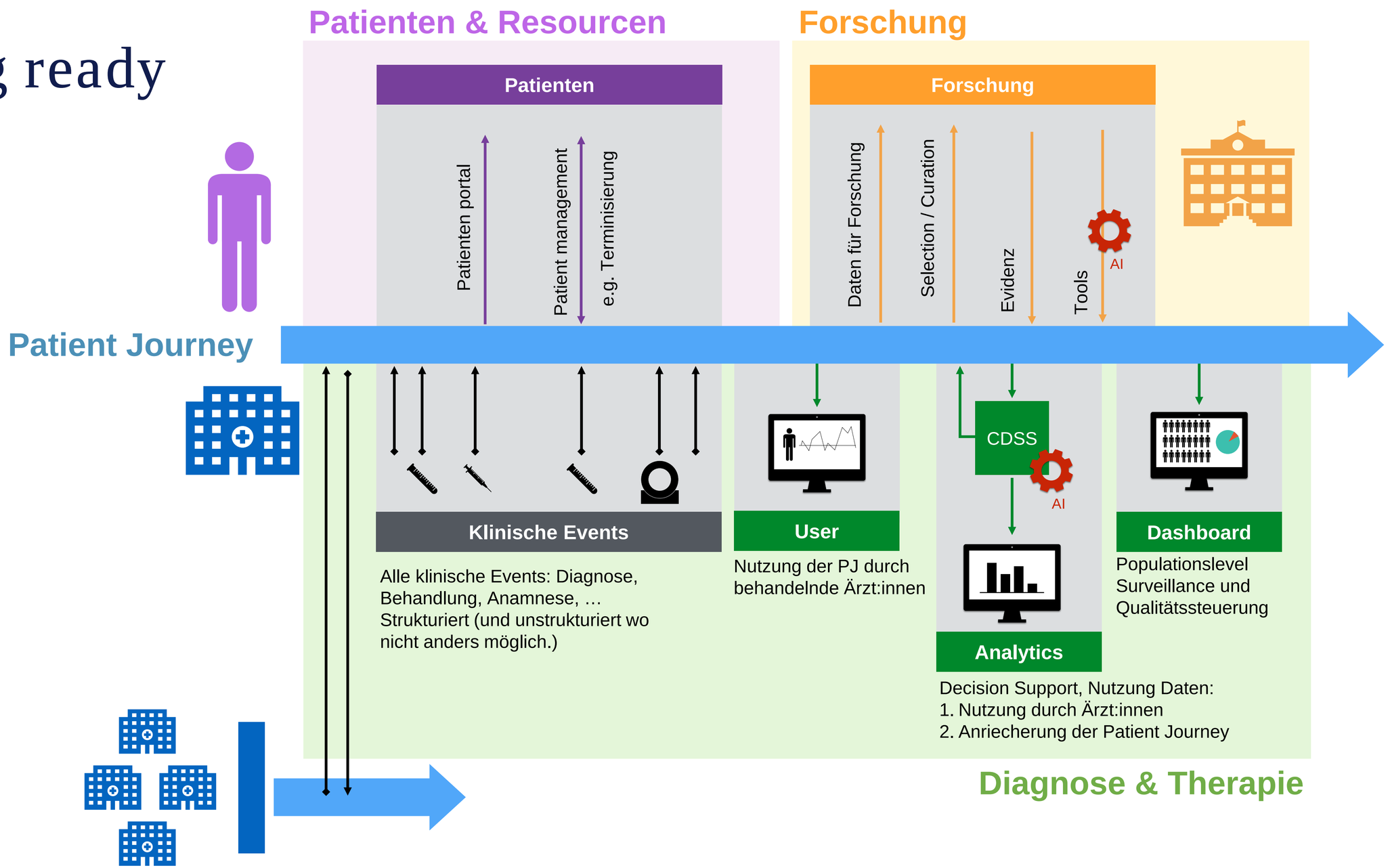


Ferber et al. Jun 2025 Nature Cancer

Implementation

Strategy & Capacity Building

Getting ready



Strategy - capacity building - streamlining

Capacity to scale

- **Streamlined processes** for purchasing: security, data protection, compliance checks
- **Exploit repeats** (platforms, platforms, platforms)
- **AI governance** processes ~ post-market surveillance

Capacity to identify usecases

- **Identify target usecases** don't be too narrow, but have KPIs
- **Bridge disciplines** (integrated diagnostics, MTB, …)
- **Levels of use:** patient, department, institution

Capacity to change workflows

- **Review workflows** and test alternatives
- **Test, iterate** and collaborate with vendors
- **Have evaluation measures**

Who

- Purchasing, IT, data protection officer
- Management

Who

- Domain experts & specialty leads
- Established interdisciplinary groups

Who

- Specialty management
- Hospital management

Summary

- Artificial Intelligence is arriving in clinical routine: *gradually and then suddenly**
- ***Don’t*** only automate individual tasks, ***do*** assess the feasibility of entirely new processes enabled by AI
- ***Don’t*** wait for products and crystal clear usecases, ***do*** work with manufacturers to steer them to your usecases
- ***Don’t*** get hung-up in efficiency, ***do*** look for added patient value and system level benefits

Acknowledging: FWF, WWTF, CD Gesellschaft, CCC Grant, EU Horizon 2020, Nationalbank Anniversary Fund, Stadt Wien, MUW-NTU, Novartis, Boehringer Ingelheim, Siemens Healthineers, NVIDIA

**Ernest Hemingway, The Sun Also Rises*