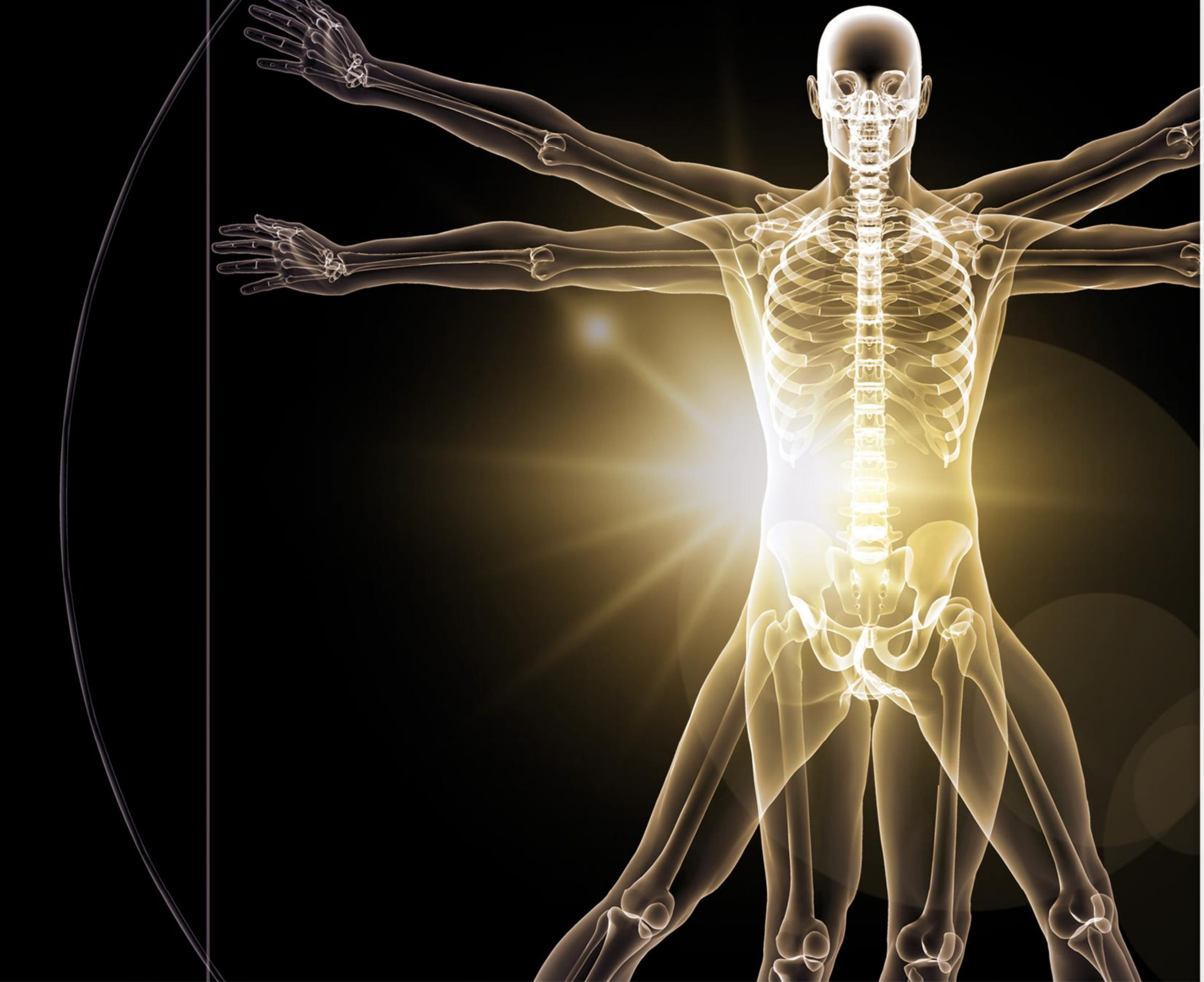


IS3R 2023

Berlin/Germany
August 24–26, 2023

Molecular Imaging (whole body PET-CT, PET-MRI) – Where are we heading?

Katrine Riklund

Professor/Senior Consultant

Radiology and Nuclear medicine

Umeå university/Umeå University Hospital

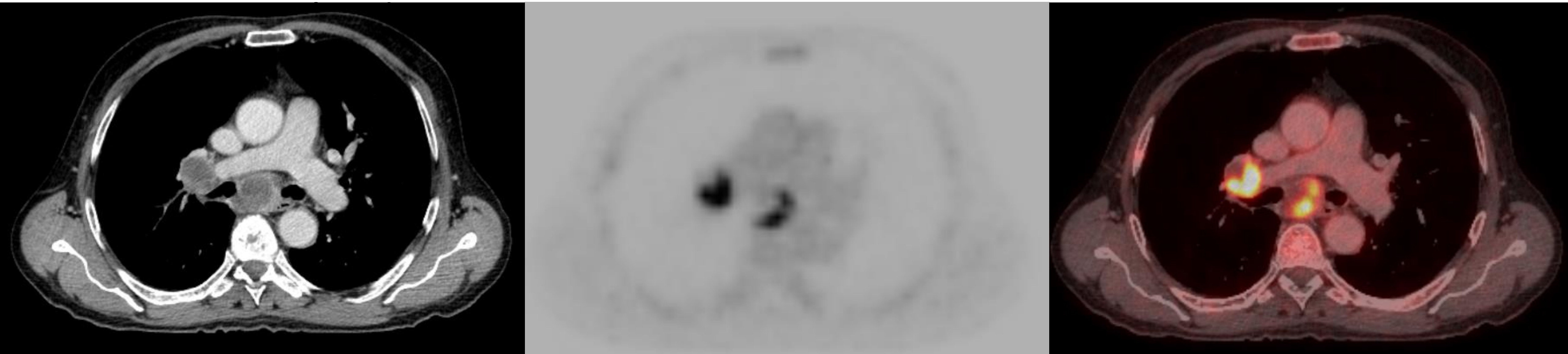
Sweden

CoI

- Collective minds radiology AB - Board member
- DICOM Port AB - Board member
- Photon Counting CT Steering Committee, GE Healthcare - Member

Hybrid Imaging → 1+1>2!

- A combination of structural and molecular imaging
- Involvement of two specialties besides the referrals
  - Structural imaging ≈ Radiology
  - Molecular Imaging ≈ Nuclear medicine



Hybrid imaging with PET/CT or PET/MR

Scanner

- PET
- CT
- MRI

Cyclotron

- Radionuclide

Active substance

- A very long list

Tracer

- Radiochemistry
- Lots of equipment

The PET

- Detector development
  - Detection material
  - Detection methods
    - Indirect – scintillation
    - Direct – semiconductor
  - Resolution
    - Intrinsic Spatial
    - Energy
    - Time
- Image Reconstruction
    - Methods
    - AI supported

Increased Image Quality and Accuracy

Topical Review

Roadmap toward the 10 ps time-of-flight PET challenge

Paul Lecoq[1], Christian Morel[2], John O Prior[3], Dimitris Visvikis[4], Stefan Gundacker[1,5], Etiennette Auffray[1], Peter Križan[6], Rosana Martinez Turtos[1,21], Dominique Thers[7], Edoardo Charbon[8], Joao Varela[9], Christophe de La Taille[10], Angelo Rivetti[11], Dominique Breton[12], Jean-François Pratte[13], Johan Nuyts[14], Suleman Surti[15], Stefaan Vandenberghe[16], Paul Marsden[17], Katia Parodi[18], Jose Maria Benlloch[19] and Mathieu Benoit[20]

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13 Interdisciplinary Institute for Technological Innovation – 3IT, Université de Sherbrooke, Canada
14 KU Leuven, Belgium
15 University of Pennsylvania, Philadelphia, PA, United States of America
16 University of Ghent, Belgium
17 School of Biomedical Engineering and Imaging Sciences, King's College, London, United Kingdom
18 Ludwig-Maximilians-Universität München, Department of Experimental Physics – Medical Physics, Munich, Germany
19 UPV, Valencia, Spain
20 Département de Physique Nucléaire et Corpusculaire (DPNC), Université de Genève, 24 Quai Ernest Ansermet, 1211, Genève 4, Switzerland
21 Institute of Physics and Astronomy, Aarhus University, 120 Ny Munkegade, 8000, Aarhus, Denmark

Phys. Med. Biol. **65** (2020) 21RM01

Total Body vs Whole Body PET/CT

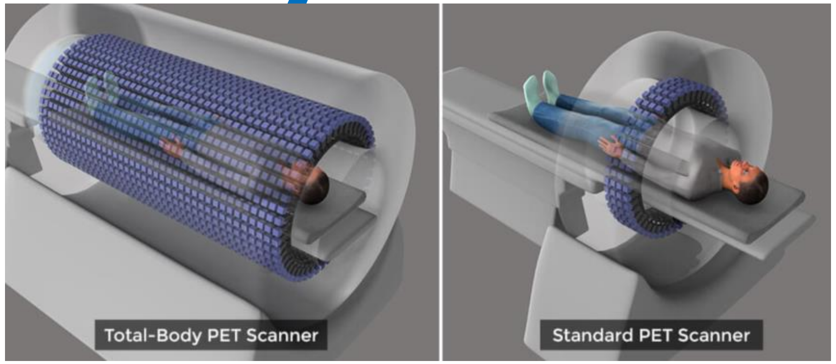
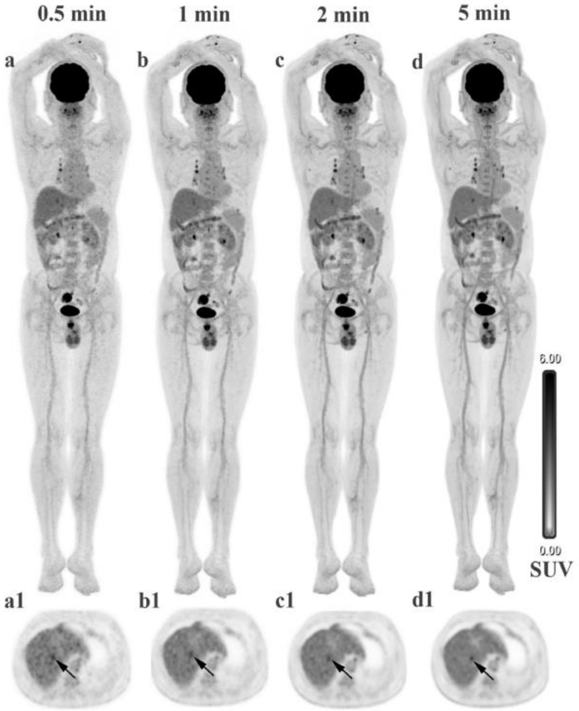
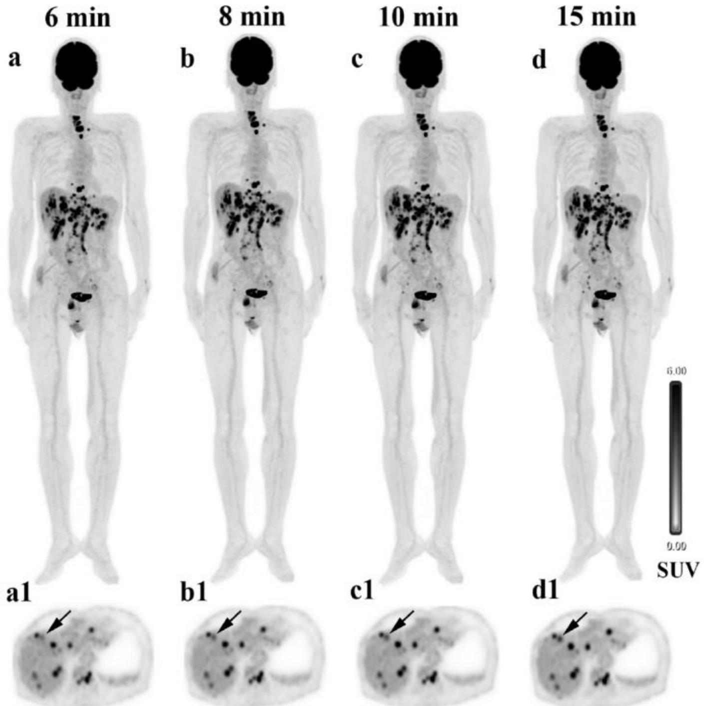


Fig. 2 Representative full-dose PET images. Male, 70 years old, height 169 cm, weight 66 kg, injected activity of 222 MBq, malignant tumor at the rectal-sigmoid junction. The acquisition time of PET imaging was 5 min, and the data was acquired in list mode. The data cutting technology was used to simulate the 0.5-min, 1-min, and 2-min images. Maximum intensity projection (MIP) (**a**, **b**, **c**, **d**) and its cross-sectional images at the liver (**a1**, **b1**, **c1**, **d1**) of 0.5-min, 1-min, 2-min, and 5-min images. Liver metastasis at the right anterior lobe of the liver (arrow), with a size of 12.9 × 11.6 mm, average CT value of 46.1 HU, and SUV_{max} of 6.9, was confirmed by surgery and pathology



Inj Dose: 222MBq FDG → ED 4mSv

Fig. 4 Representative ultra-low-dose PET images. Male, 67 years old, height 168 cm, weight 55 kg, injected activity of 21.46 MBq, with intrahepatic cholangiocarcinoma. The acquisition time of PET imaging was 15 min, and the data was acquired in list mode. The data cutting technology was used to simulate the 6-min, 8-min, and 10-min images. MIP (**a**, **b**, **c**, **d**), its cross-sectional images at the liver (**a1**, **b1**, **c1**, **d1**) of 6-min, 8-min, 10-min, and 15-min images. Small lesions with slight uptake of [^{18}F]FDG in the liver parenchyma can be clearly displayed (arrows)



Inj Dose: 21.5 MBq FDG → ED 0.4mSv

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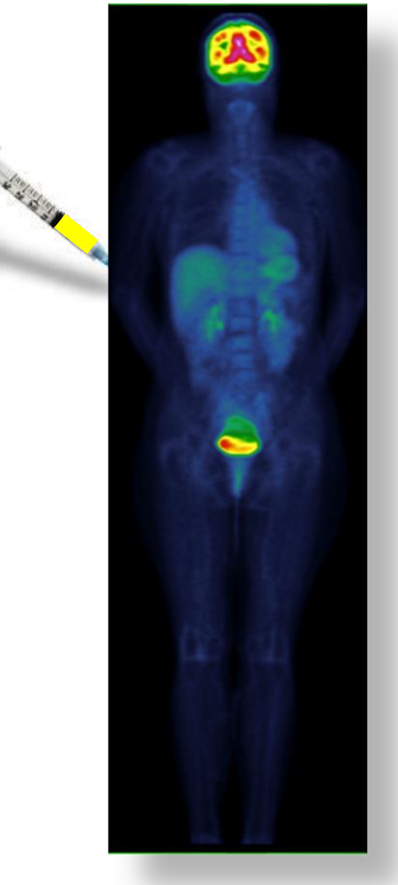
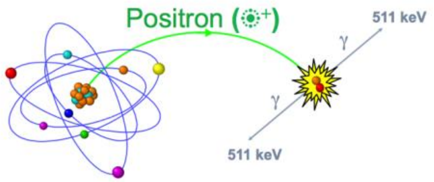
Yu et al *616 European Radiology (2023) 33:615–626*

The Tracer is the Key



PET



Tracer

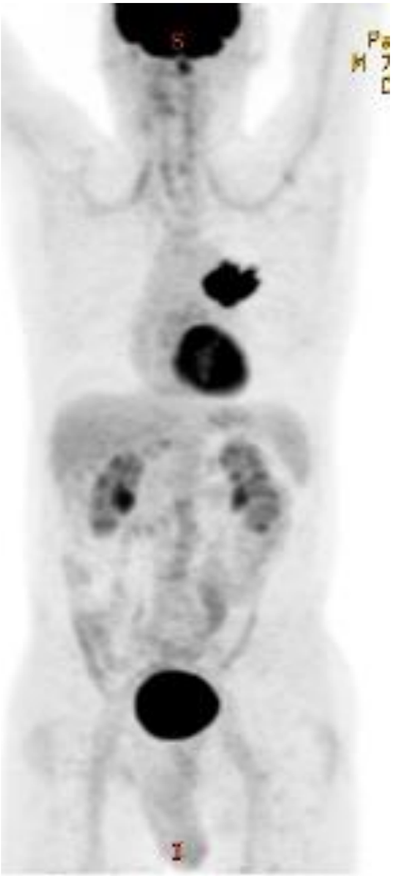
^{18}F or ^{11}C or ^{15}O

and

Active substanse

(FDG or ACE or….)

Metabolism
Receptors
Perfusion
Amino acid
Fatty acid
….

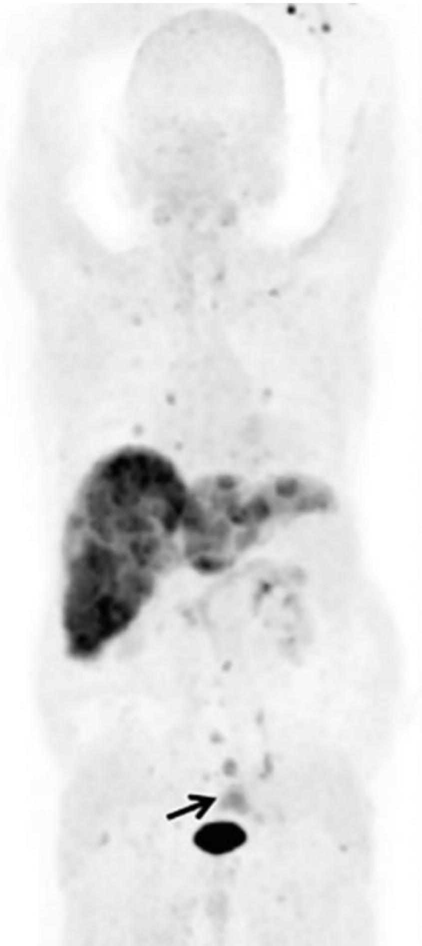


FDG

Metabolism

PSMA

Prostate Specific Antigen



FAPI

Activated Fibroblasts

NAF

Ostogenesis

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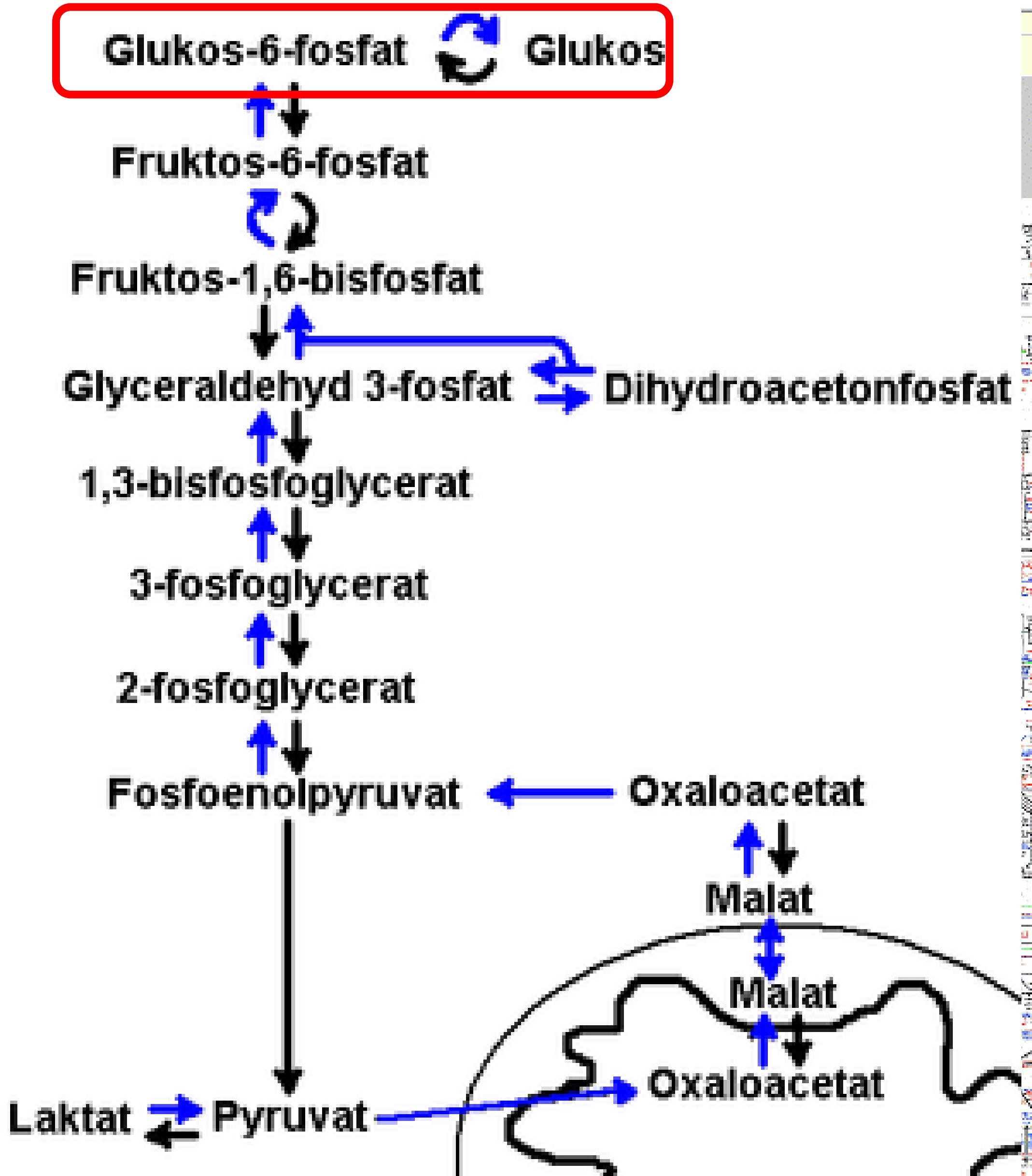
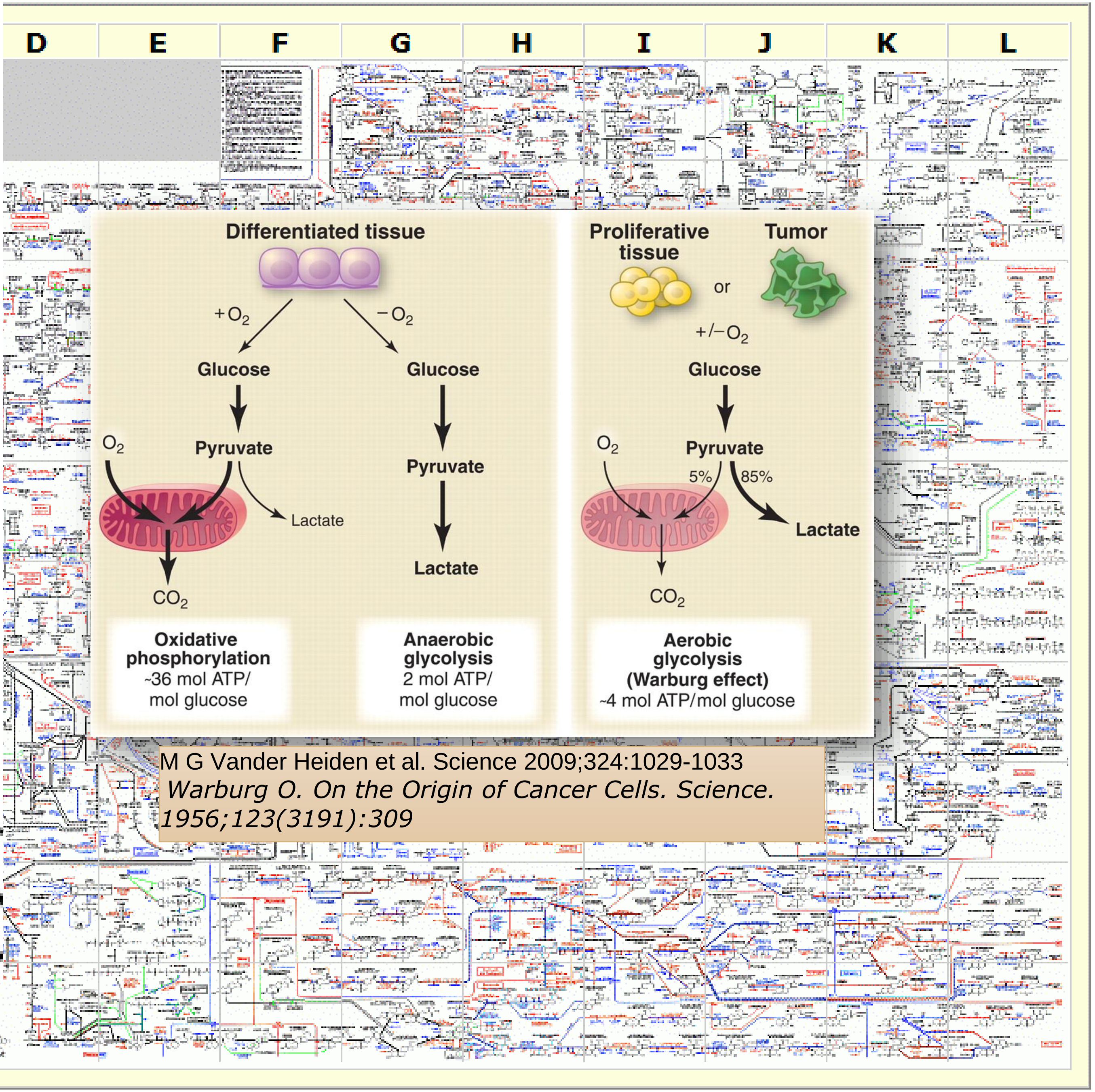
Cheng et al *J. Clin. Med.* 2023,





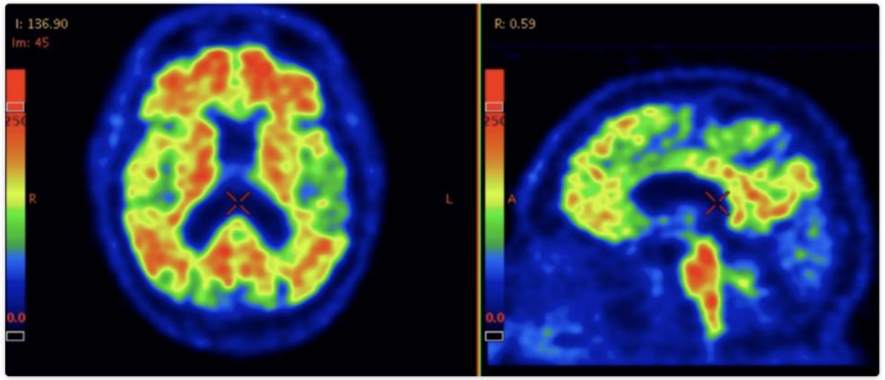
M G Vander Heiden et al. Science 2009;324:1029-1033

Warburg O. On the Origin of Cancer Cells. Science. 1956;123(3191):309

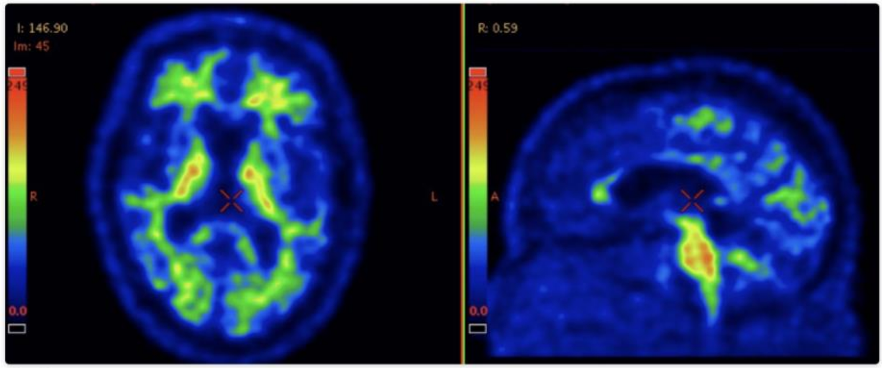
Tracer Distribution

THE SWEDISH BIOFINDER STUDY™

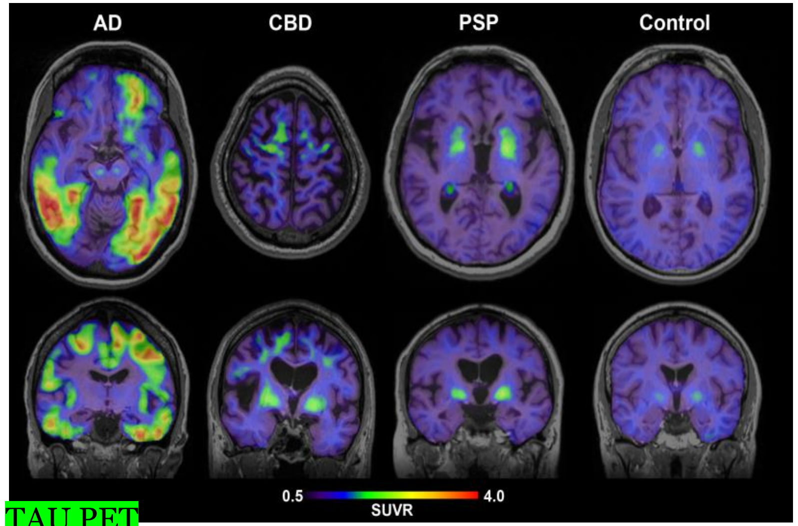
Amyloid PET imaging



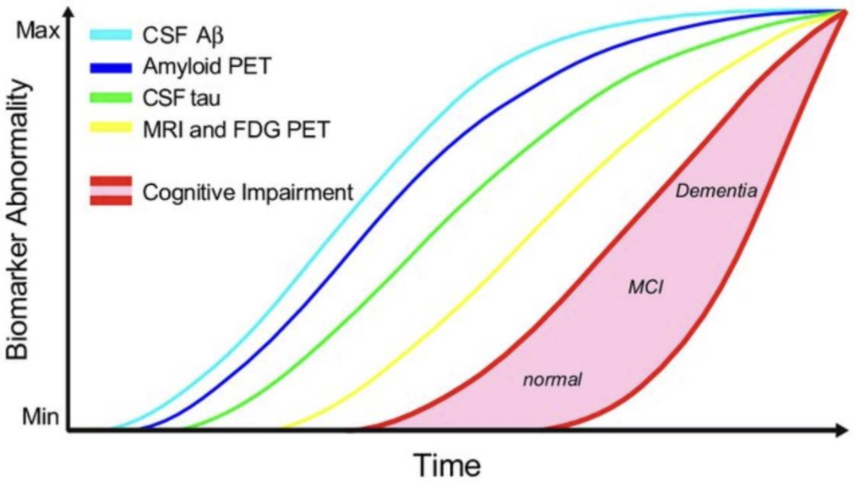
[18]F-flutemetamol amyloid PET in an MCI patient that later developed AD



[18]F-flutemetamol amyloid PET in a cognitively healthy elderly



TAU PET



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AI in Hybrid Imaging

Seminars in NUCLEAR MEDICINE

Role of Artificial Intelligence in PET/CT Imaging for Management of Lymphoma

Eren M. Veziroglu, MS,[†] Faraz Farhadi, BS,[*,†] Navid Hasani, BS,[*] Moozhan Nikpanah, MD,[*,‡] Mark Roschewski, MD,[§] Ronald M. Summers, MD, PhD,[*,||] and Babak Saboury, MD,MPH[*]

Our review shows that AI-based analysis of lymphoma whole-body FDG-PET/CT can inform all phases of clinical management including staging, prognostication, treatment planning, and treatment response evaluation. We highlight advancements in the role of neural networks for performing automated image segmentation to calculate PET-based imaging biomarkers such as the total metabolic tumor volume (TMTV). AI-based image segmentation methods are at levels where they can be semi-automatically implemented with minimal human inputs and nearing the level of a second-opinion radiologist. Advances in automated segmentation methods are particularly apparent in the discrimination of lymphomatous vs non-lymphomatous FDG-avid regions, which carries through to automated staging. Automated TMTV calculators, in addition to automated calculation of measures such as Dmax are informing robust models of progression-free survival which can then feed into improved treatment planning.

Semin Nucl Med 53:426-448 © 2022 Published by Elsevier Inc.

The role of artificial intelligence based on PET/CT radiomics in NSCLC: Disease management, opportunities, and challenges

Qiuyuan Hu[1†], Ke Li[2†], Conghui Yang[1†], Yue Wang[1], Rong Huang[1], Mingqiu Gu[1], Yuqiang Xiao[1], Yunchao Huang[3*] and Long Chen[1*]

Conclusion: AI-based PET/CT Radiomics play potential roles in NSCLC clinical management. However, there is still a long way to go before being translated into clinical application. Large-scale, multi-center, prospective research is the direction of future efforts, while we need to face the risk of repeatability of radiomics features and the limitation of access to large databases.

frontiers | Frontiers in Oncology
TYPE Review
PUBLISHED 07 March 2023
DOI 10.3389/fonc.2023.1133164

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Review Article on Artificial Intelligence in Molecular Imaging
Page 1 of 1

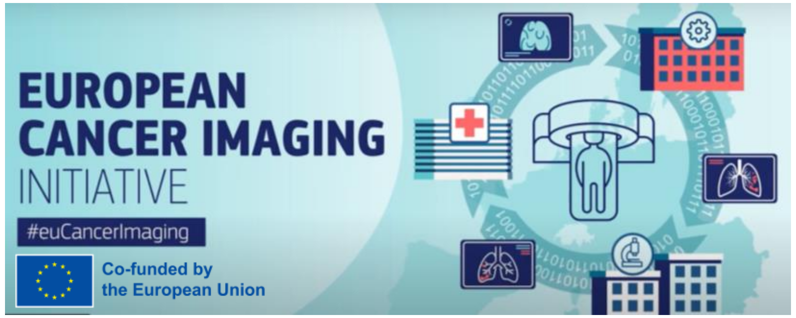
Applications of artificial intelligence in oncologic ^{18}F-FDG PET/CT imaging: a systematic review

Mohammad S. Sadaghiani, Steven P. Rowe, Sara Sheikhbahaei

The routine implementation of AI-based models and 18F-FDG PET-derived radiomics in clinical practice is currently limited, due to lack of standardized, reproducible, generalizable, and precise techniques. Regarding the ML-based models, there are a few challenging steps still required to be achieved.

Ann Transl Med 2021;9(9):823

datasciencecentral.com



Seminars in NUCLEAR MEDICINE

Artificial Intelligence for Optimization and Interpretation of PET/CT and PET/MR Images

Greg Zaharchuk, MD, PhD,[*] and Guido Davidzon, MD, SM[†]

Semin Nucl Med 51:134-142 © 2020 Published by Elsevier Inc.

Conclusion

In summary, there is much activity in the field of AI for improving both the image quality, safety, and utility of PET/CT and PET/MRI for molecular imaging. There remain many challenges involving the acquisition and curation of large medical datasets, in representative populations, and with adequate representation of major imaging vendors. One key need is the collaboration of AI scientists, molecular imaging researchers, and physicians to ensure that the use cases explored and the algorithms developed are those that will push the field forward to explore new and exciting innovations and ultimately to add value to improve patient care.

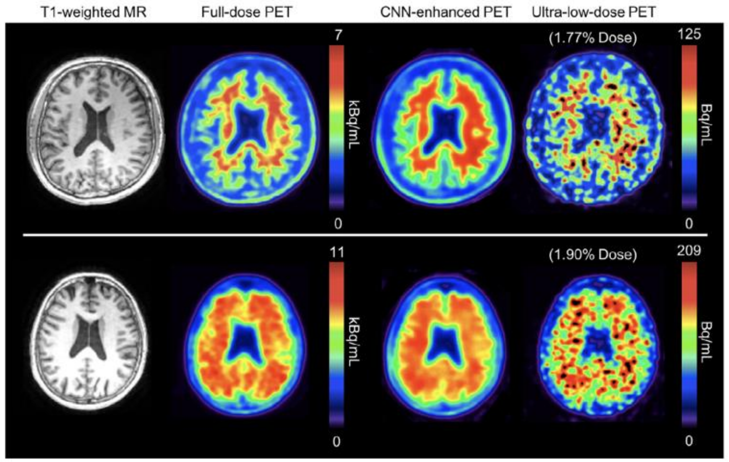
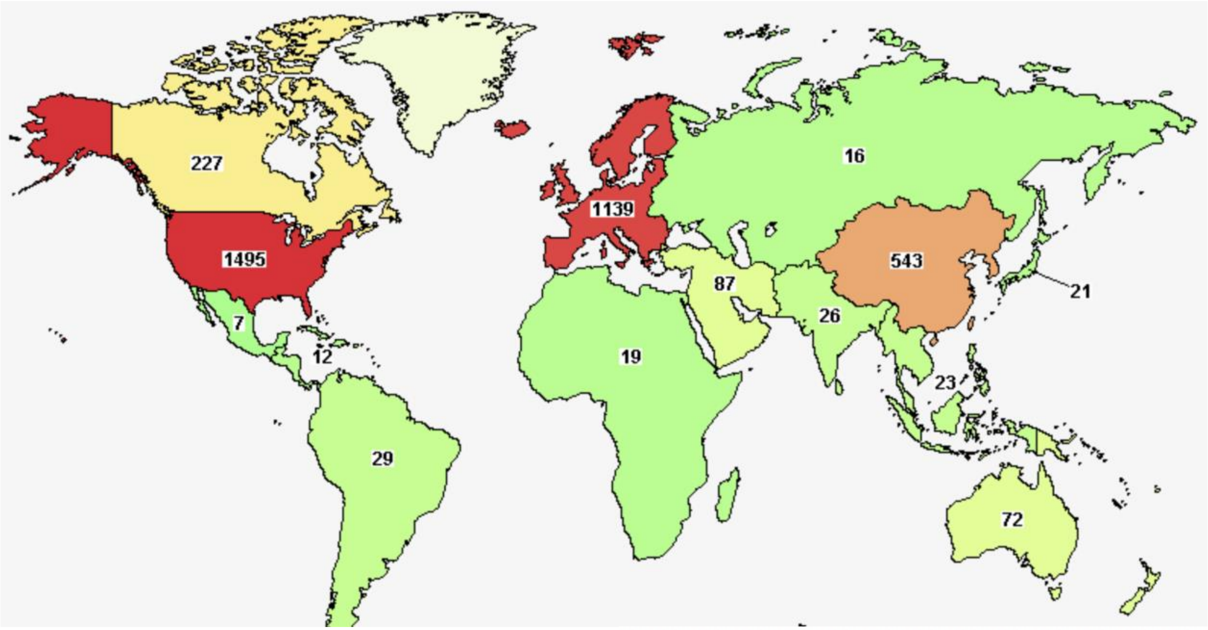
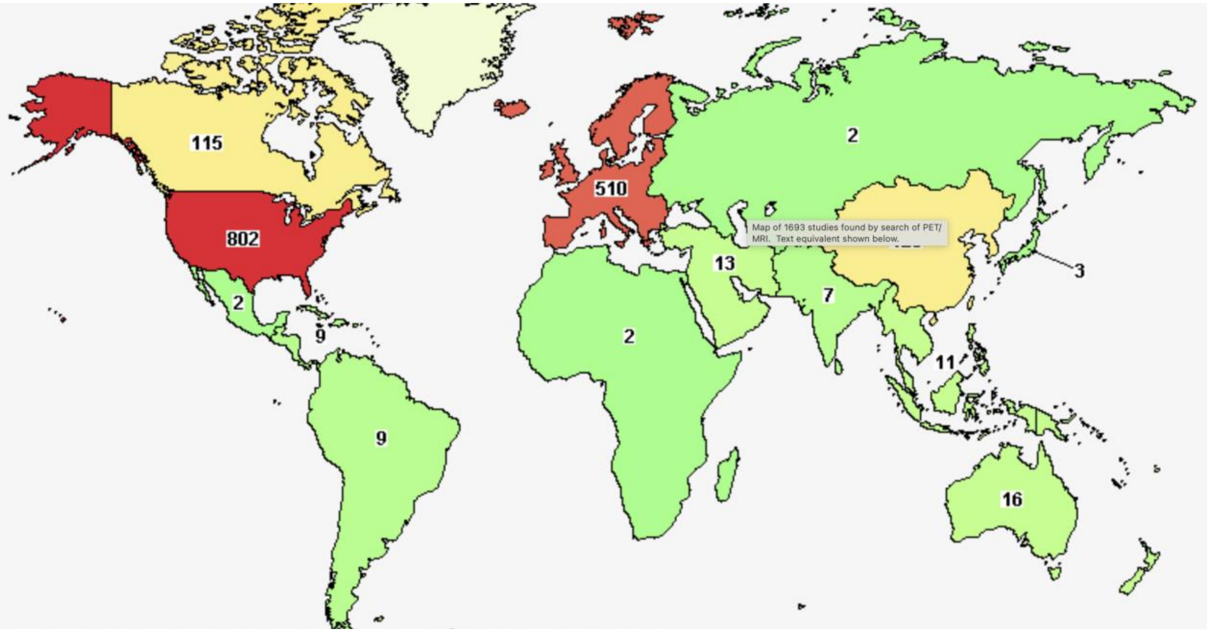


Figure 1 Examples of actual ultralow dose amyloid PET in patients with a negative study (top) and positive (bottom) amyloid study. The CNN-enhanced PET shows marked noise reduction and similar biodistribution to the full-dose PET.

2023 PET/CT and PET/MRI Clinical Studies

What we can do – What we should do?





Clinical Drug Investigation
https://doi.org/10.1007/s40261-023-01285-4

ORIGINAL RESEARCH ARTICLE

Cancer Drugs Reimbursed with Limited Evidence on Overall Survival and Quality of Life: Do Follow-Up Studies Confirm Patient Benefits?

Gabriella Chauca Strand[1,6] · Naimi Johansson[1,2] · Niklas Jakobsson[3] · Carl Bonander[1,4] · Mikael Svensson[1,5]

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"A considerable share of reimbursed cancer drug indications continue to lack evidence of improvement in both OS and QoL."

Competition Between Modalities

ELSEVIER

Seminars in NUCLEAR MEDICINE

52:356, 2021

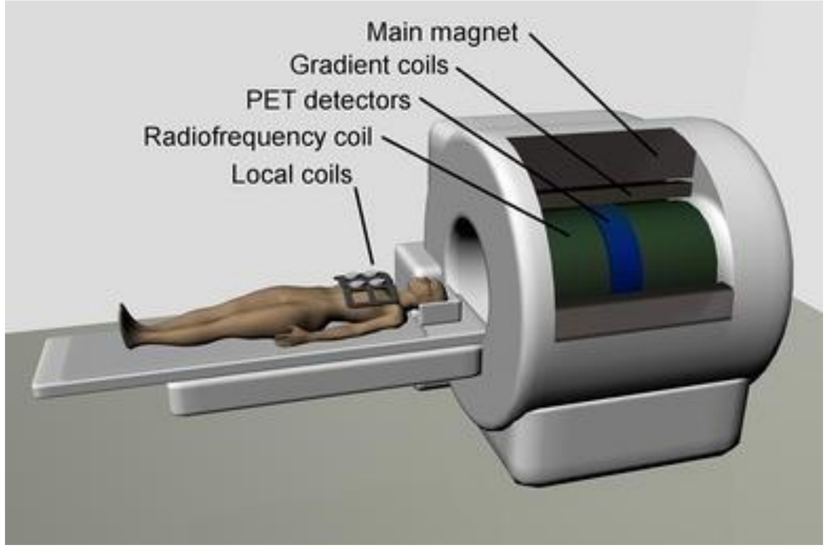
Clinical Use of PET/MR in Oncology: An Update

Robert Seifert, MD,[*,†,‡,§] David Kersting, MD,[*,‡,§] Christoph Rischpler, MD,[*,‡,§]
Marcel Opitz, MD,[‖] Julian Kirchner, MD,[¶] Kim M. Pabst, MD,[*,‡,§]
Ilektra-Antonia Mavroeidi, MD,[‡,#] Christina Laschinsky, MD,[*,‡,§] Johannes Grueneisen, MD,[‖]
Benedikt Schaarschmidt, MD,[‖] Onofrio Antonio Catalano, MD,PhD,[**,††]
Ken Herrmann, MD,[*,‡,§] and Lale Umutlu, MD[‖]

Neuro-oncology
Head & Neck Tumours
Breast Cancer
Prostate Cancer
Sarcoma

Conclusion

The integrated use of parametric MRI together with PET imaging has demonstrated its clinical advantages in many oncology settings. PET/MRI applications are increasing in clinical routine imaging and gaining ground as the potential of MRI is being fully exploited. Nevertheless, future studies should focus on evaluating the use of PET/MRI with novel tracers, novel hard- and software technology, AI and radiomics as well as multiparametric MRI in multicentric patient cohort settings.



PET/CT or PET/MR
vs
MR or CT?

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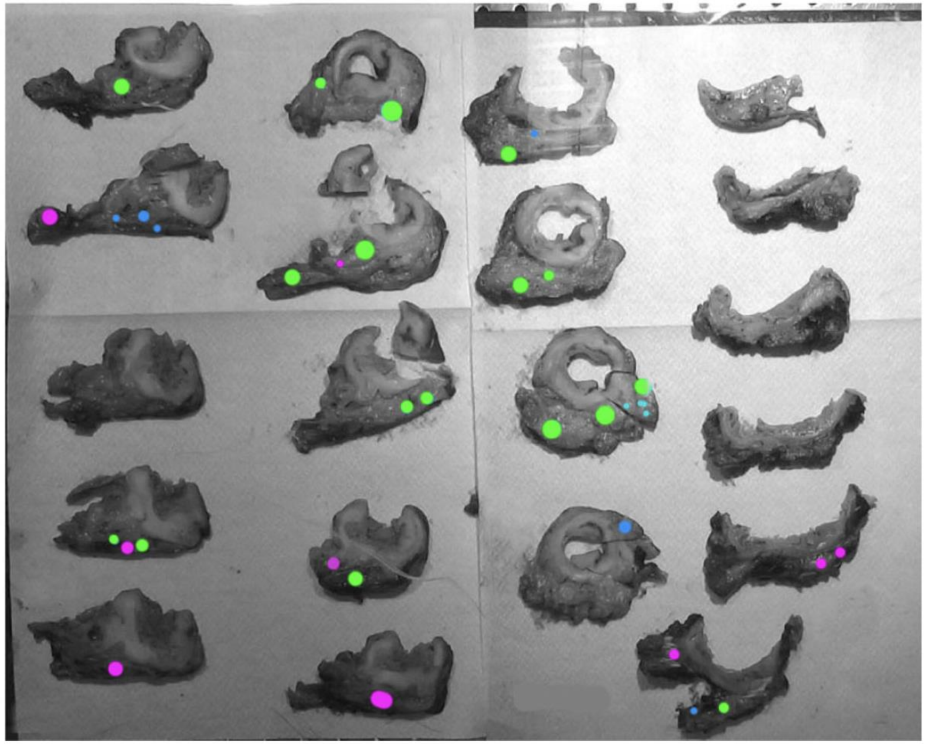
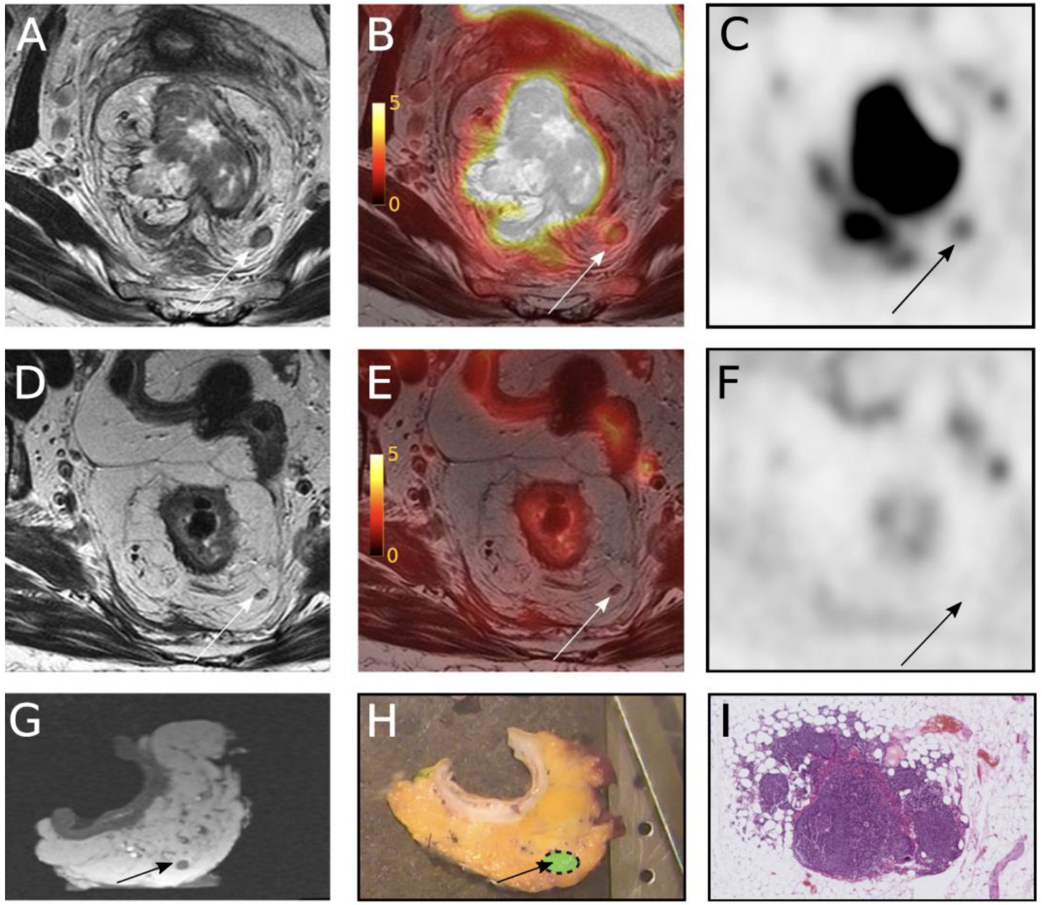
Rectal cancer: a methodological approach to matching PET/MRI to histopathology





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Rutegård et al. Cancer Imaging (2020) 20:80

Hybrid Imaging - Where are we Heading?

HW development → Increased accuracy

- Detector Development
- WB PET/CT and PET/MR
  - Stand alone → HW integration
- Whole Body → Total Body
  - Added Value?
  - Challenges

Tracer Development → Research and Clinical Needs

- Cyclotron
- Radiochemistry
- Legal Issues

AI → Validate – Translate - Use

- Collaboration Radiology/Nuclear Medicine and AI-”developers”
- Robust Image Data Bases
- Legal Issues

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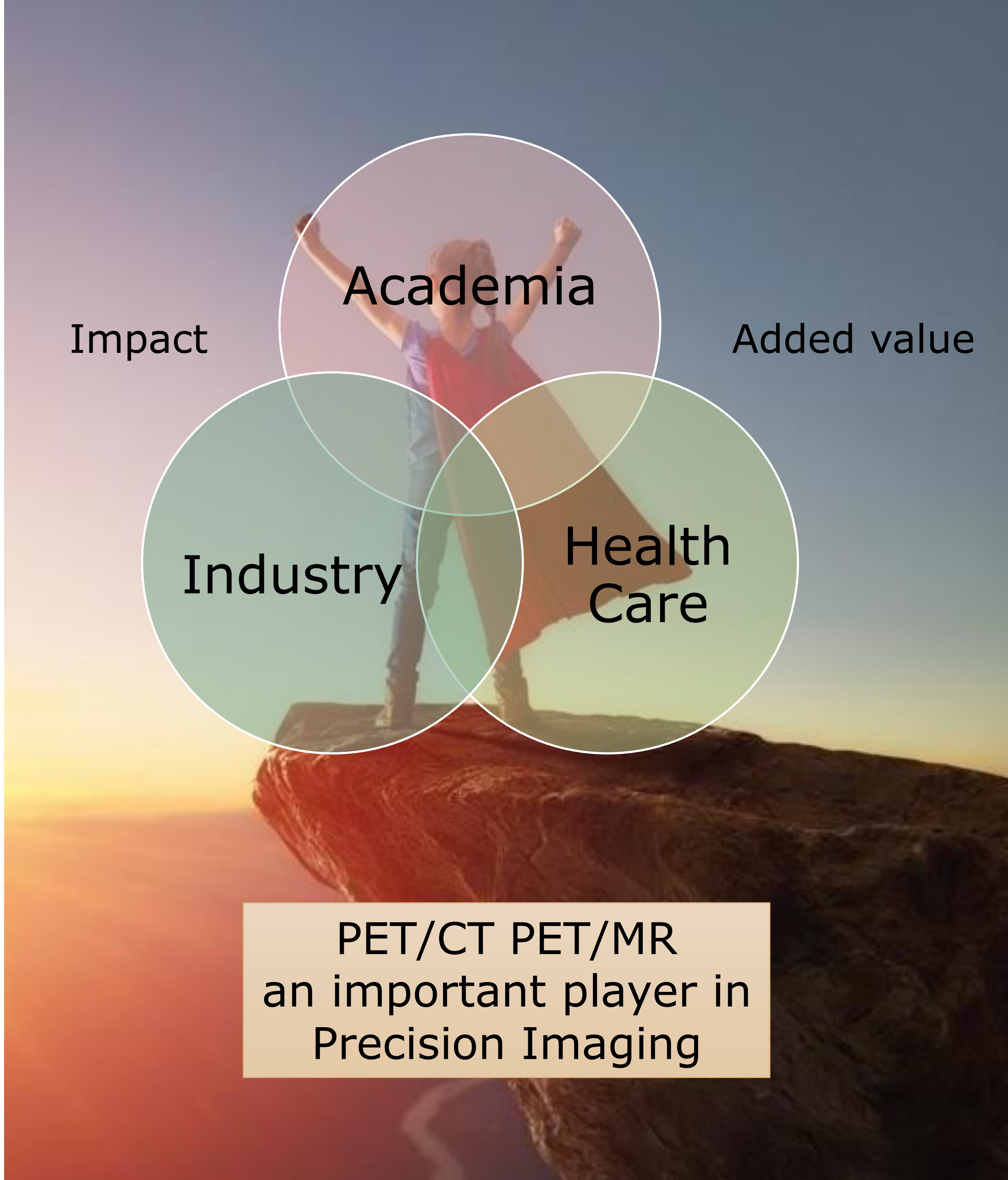

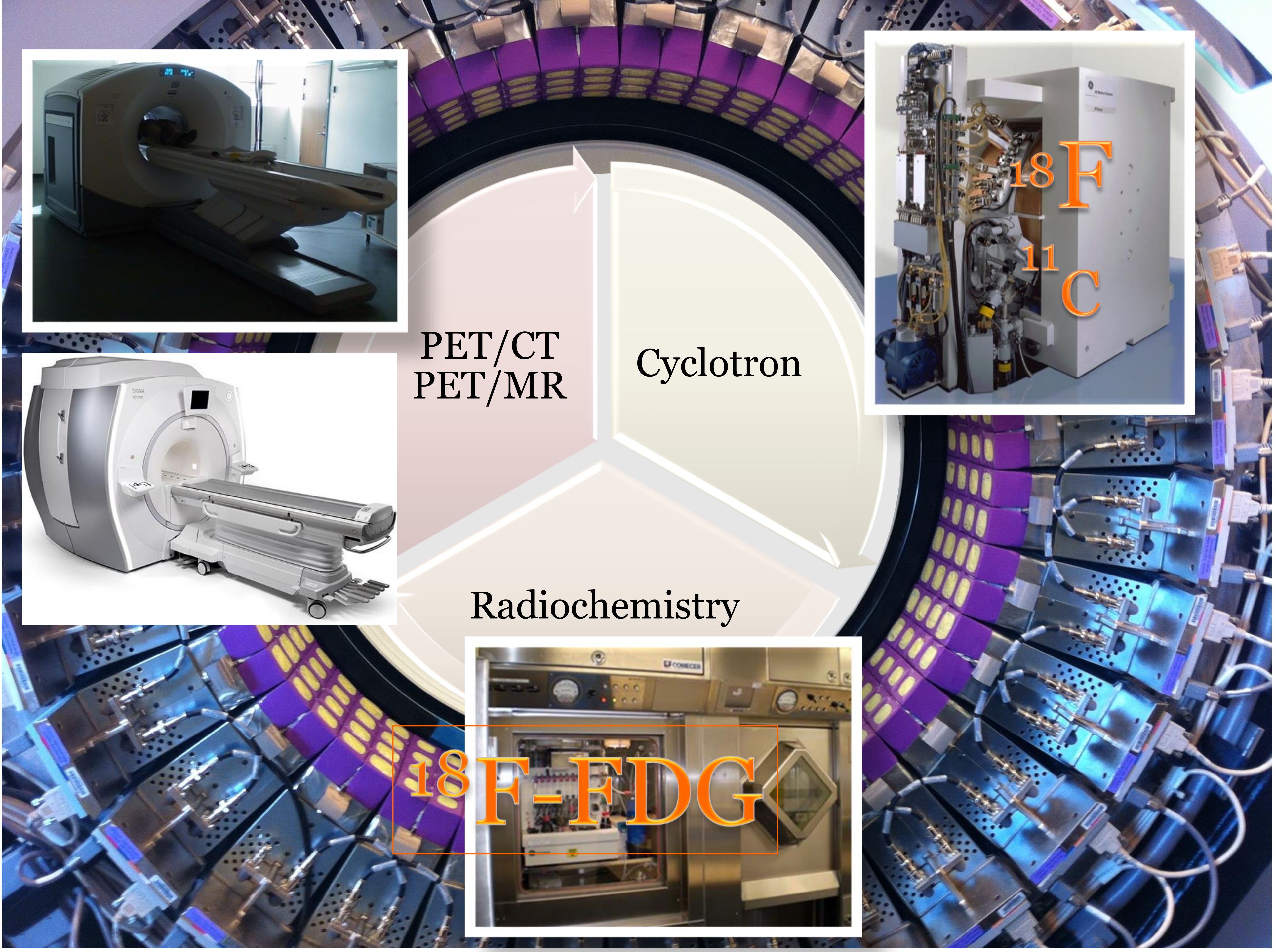

Chat GPT suggestions

- Enhanced Image Quality and Resolution
- Quantitative Imaging
- Combining Modalities
- Theranostics
- New Tracers
- Neurodegenerative Diseases
- Cancer Research
- Data Integration and AI
- Radiomics and Radiogenomics

Thank you!

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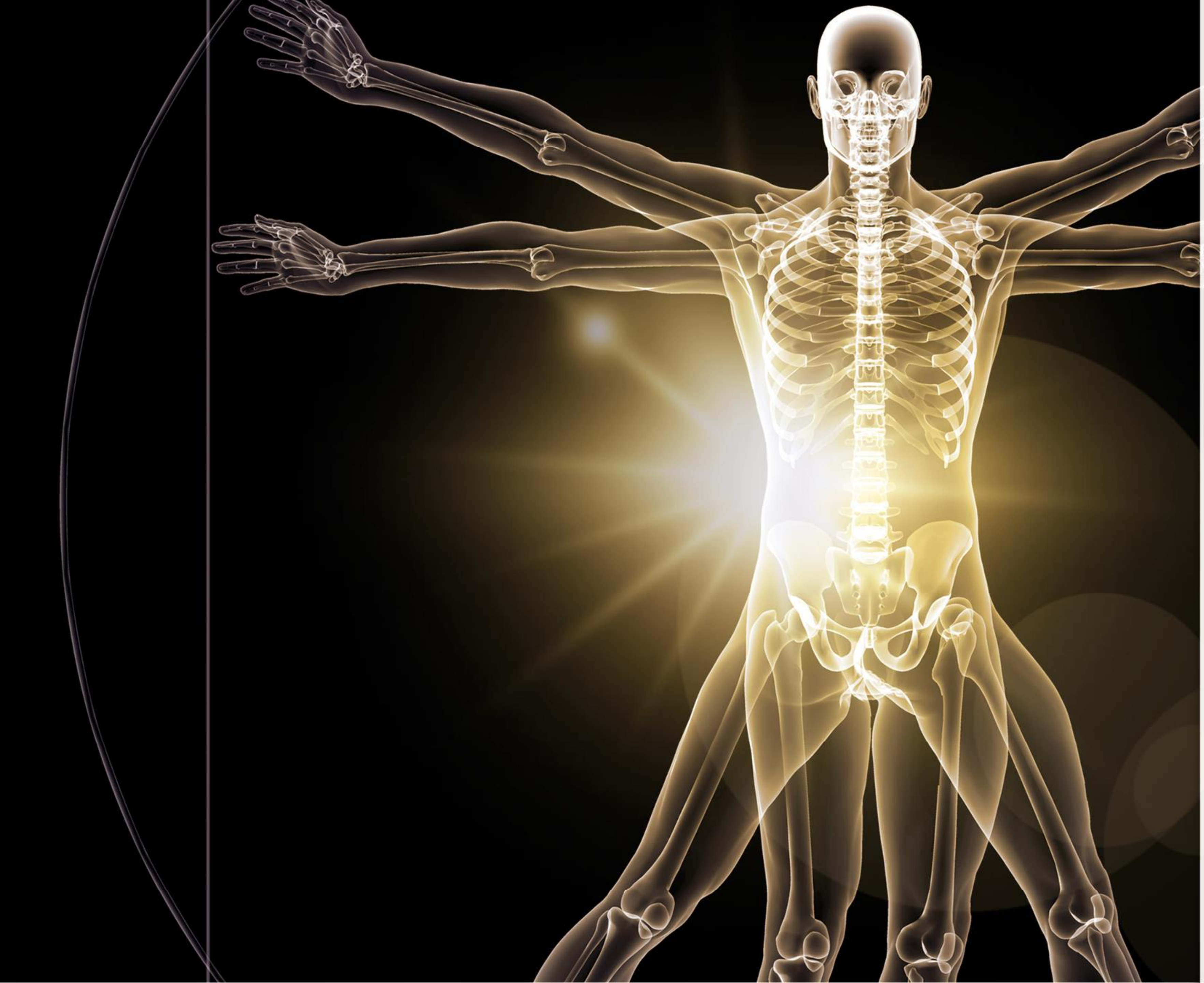
region västerbotten

UFBI Umeå center for Functional Brain Imaging

ESR EUROPEAN SOCIETY OF RADIOLOGY

ESHI MT EUROPEAN SOCIETY FOR HYBRID, MOLECULAR AND TRANSLATIONAL IMAGING



15th Biennial Symposium of the International Society for Strategic Studies in Radiology

IS3R 2023

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