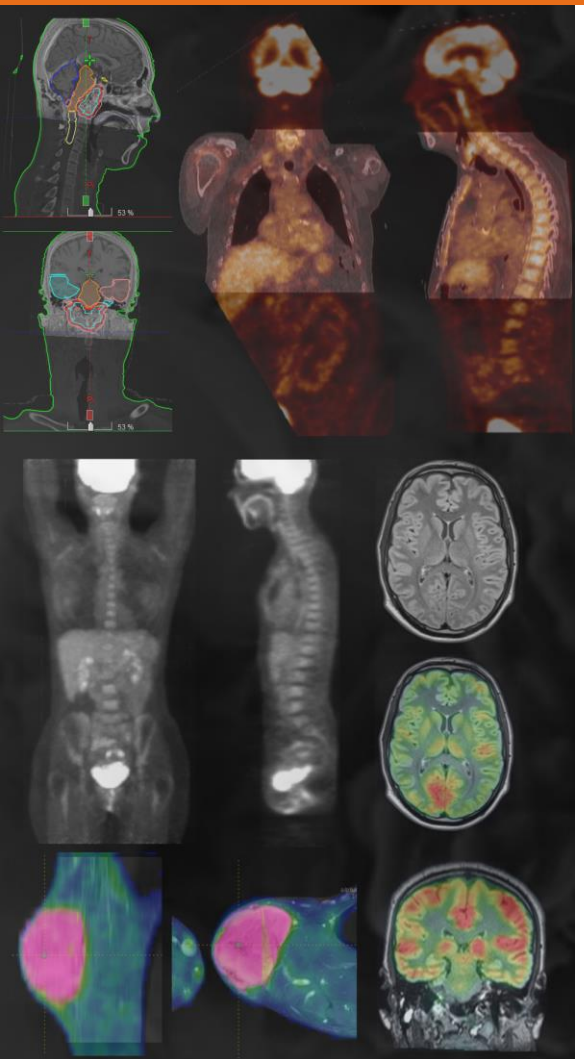


Retour SNMMI 2024

11/09/24

Eligibility to PSMA-RLT based on dual FDG/PSMA-PET: a subanalysis of the 3TMPO study

Jean-Mathieu Beauregard, Etienne Rousseau, Atefeh Zamanian, Fred Saad, Patrick Richard, Stephan Probst, Éric Lévesque, Vincent Castonguay, Nicolas Marcoux, Michele Lodde, Daniel Juneau, Zineb Hamilou, Jean-Baptiste Lattouf, François-Alexandre Buteau, Michel Pavic, Jean-François Castilloux, Bertrand Neveu, Guillaume Bouvet, Catherine Allard, Amélie Tétu, Brigitte Guerin and Frédéric Pouliot

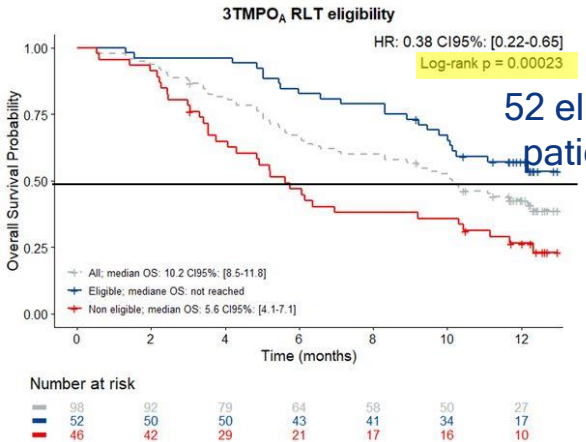
Journal of Nuclear Medicine June 2024, 65 (supplement 2) 241044;

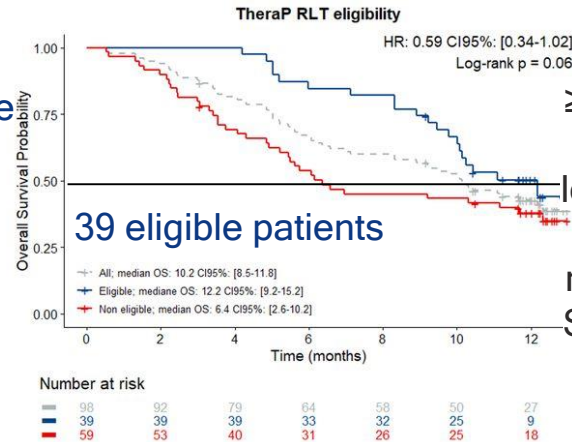
Introduction: Eligibility criteria for PSMA-RLT are currently debated, particularly with respect to the role of FDG-PET in patient selection. We are proposing new imaging eligibility criteria for PSMA-RLT based on dual-tracer FDG/PSMA-PET that do not rely on lesion size on CT. The aims of this analysis were to compare these new criteria with those of the TheraP and VISION trials when applied in a prospective cohort of patients with metastatic castration-resistant prostate cancer (mCRPC) and to correlate the RLT eligibility with overall survival (OS).

Methods: Ninety-eight patients with progressive mCRPC and at least three metastases on conventional imaging were enrolled in 3TMPO, a multicenter prospective cohort study investigating the intrapatient intermetastatic heterogeneity with multi-tracer PET/CT (NCT04000776). All participants underwent ^{18}F-FDG and ^{68}Ga-PSMA-617 PET/CT within ten days. Lesions that were analyzed had a molecular tumor volume ≥1 cc on either PET when segmented using a threshold of 1.5x liver SUV_{mean}. For each lesion and tracer, the ratio of SUV_{peak} to liver SUV_{mean} (SUVR) was computed. Eligibility to RLT was defined as having at least one PSMA+ lesion and no FDG+/PSMA- lesion.

Eligibility to PSMA-RLT based on dual FDG/PSMA-PET: a subanalysis of the 3TMPO study

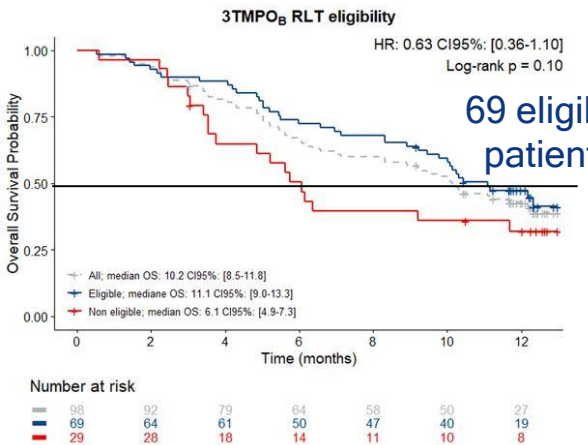
$3TMPO_A$= the protocol's prespecified threshold of SUVR ≥ 1.5 for both tracers

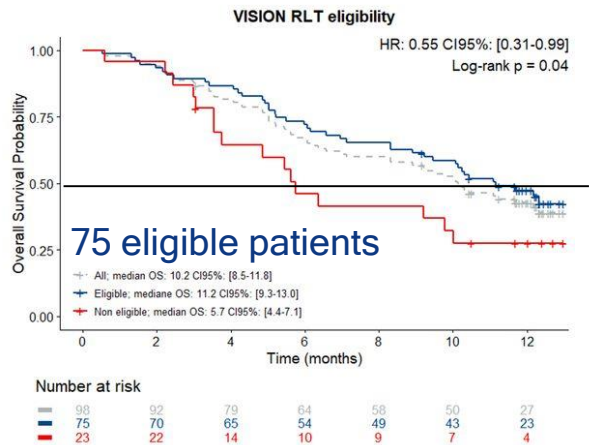




TheraP =
≥1 lesion with SUV_{max} ≥20;
all CT-measurable lesions/nodes ≥10 mm with SUV_{max} ≥10;
no FDG+ lesion with PSMA SUV_{max} <10 or FDG>PSMA

$3TMPO_B$ = relaxed thresholds of SUVR ≥ 2.0 for FDG and of SUVR ≥1.0 for PSMA

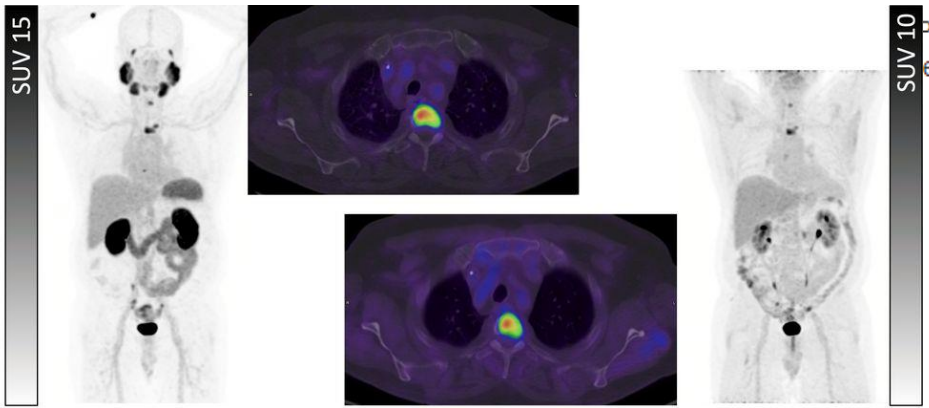




VISION =
≥1 lesion with PSMA uptake > liver;
no bone superscan;
no CT-measurable soft-tissue lesion ≥10 mm or node ≥ 25 mm with PSMA uptake < liver

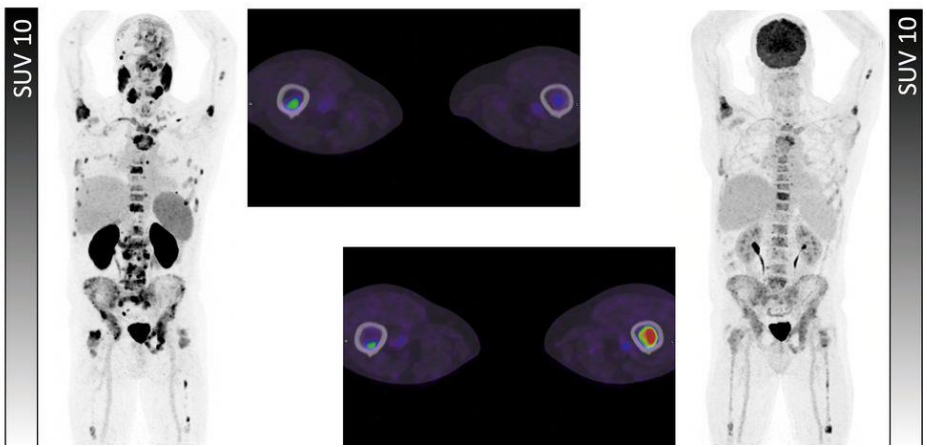
Eligibility to PSMA-RLT based on dual FDG/PSMA-PET: a subanalysis of the 3TMPO study

A. 64 y.o. mCRPC patient ineligible to RLT based on TheraP criteria (no lesion with PSMA SUV_{max}≥20), but eligible according to $3TMPO_A$, $3TMPO_B$ and VISION. He received RLT and was still alive at 13.0 mo. follow-up.



PSMA FDG

B. 67 y.o. mCRPC patient eligible to RLT based on VISION criteria, but ineligible according to $3TMPO_A$, $3TMPO_B$ and TheraP (FDG+/PSMA- bone lesions). He received RLT and deceased at 5.2 mo.



Probst, Éric Lévesque, Vincent Castonguay, Nicolas Marcoux,
el Pavic, Jean-François Castilloux, Bertrand Neveu, Guillaume Bouvet,

Conclusions: We propose two novel dual FDG/PSMA PET-based RLT eligibility criteria sets - one more selective and one more permissive - that would both allow more mCRPC patients to receive PSMA-RLT than the TheraP criteria yet would still exclude those patients with poorly targeted, significantly hypermetabolic lesions (including bone metastases) otherwise permitted by the VISION criteria and associated with a poor prognosis. Our pragmatic dual-PET quantitative criteria sets thus appear reasonably balanced between the most frequently cited ones, and their adoption in clinical trials would allow to prospectively fill the knowledge gap regarding the benefits - or the lack thereof - of PSMA-RLT in patients harboring FDG+ lesions with borderline PSMA expression.

Comparative Analysis of Large Language Models: ChatGPT and Google Bard Answer Non-Expert Questions Related to the Diagnostic and Therapeutic Applications of PSMA in Patients with Prostate Cancer

Julie Hong[1], Jeremie Calais[1], Matthias Benz[1,2], Martin Allen-Auerbach[1], Ali Salavati[1,2]
[1] UCLA Department of Molecular and Medical Pharmacology
[2] UCLA Department of Radiology

INTRODUCTION

- Prostate-specific membrane antigen (PSMA)-targeted radiopharmaceuticals (hereafter referred to as PSMA agents) have shown promising results in imaging and treatment of prostate cancer.
- To help better understand their diagnosis or therapy options, patients diagnosed with prostate cancer commonly turn to easily accessible information sources, including online Large Language Models (LLMs). ChatGPT[1] and Google Bard[2] are two widely available LLMs that use deep learning techniques to train on an extensive amount of language data to mimic human language processing capabilities.

Bard OpenAI ChatGPT

- The objective of this study is to evaluate the performance of ChatGPT and Google Bard in answering nonexpert questions concerning the diagnostic and therapeutic applications of PSMA in the management of patients with prostate cancer.

MATERIALS & METHODS

- Real-life, representative sample of patient questions regarding PSMA study and therapies were created by nuclear medicine physicians. The study sample consisted of 30 questions regarding diagnostic aspects of PSMA PET/CT (Table 1) and 35 questions regarding therapeutic aspects of PSMA PET/CT (Table 2).
- These questions were presented to ChatGPT-3.5 and Google Bard. The answers were reviewed by three nuclear medicine physicians independently.
- The responses were recorded and assessed for accuracy with the following scores:

0	Responses clearly misleading; LLM fabricated reference or concepts
1	Unanswered or incorrect
2	Partially correct
3	Correct
4	Perfect response with simplex explanation written like an expert

- Responses from the three reviewers were then combined by majority votes (correct, partially correct, and incorrect/no answer/confabulation), and then the proportion of 95% CI for each category of answers were calculated (Table 3).
- Mixed-effects logistic regressions were performed to compare the accuracy among ChatGPT and Google Bard responses.

RESULTS

Table 1: Accuracy of Responses Provided by ChatGPT and Google Bard to Questions regarding Diagnostic Applications of PSMA PET/CT

	ChatGPT			Google Bard		
Questions	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 1	Reviewer 2	Reviewer 3
What is PSMA PET/CT?	4	4	3	1	4	3
Is PSMA Imaging approved by the U.S. Food and Drug Administration?	1	2	2	1	3	4
What is PSMA Imaging approved for?	1	2	2	3	4	3
Will my health insurance pay for a PSMA PET/CT?	3	3	2	1	4	4
Is radiation from PSMA PET/CT dangerous?	4	4	2	1	3	2
What are the side-effects of PSMA PET/CT?	4	3	2	1	2	2
How accurate is PSMA PET/CT in finding prostate cancer?	4	4	2	1	3	4
My radiology report says "my tumor shows PSMA uptake." What does it mean?	2	4	2	4	4	4
Can I get screened for prostate cancer using PSMA PET/CT?	3	4	3	1	1	1
Do I need to get a PET/CT if my biopsy shows prostate cancer?	3	4	2	1	4	2
Do I need to get a PET/CT if my prostate MRI shows a suspicious finding?	3	4	2	4	4	2
Do I need to get a PSMA PET/CT if my PSA is rising after prostatectomy?	2	4	0	4	4	2
Are there different PET radiotracers for imaging prostate cancer?	1	3	2	2	1	2
What are the minimum PSA levels I should have to do a PET/CT scan?	2	4	2	1	1	2
What are the differences between PSMA PET/CT and Axumin PET/CT?	1	4	4	1	2	2
What are the differences between PET/CT and PET/MRI?	2	4	2	2	3	2
Which one is better PET/CT or PET/MRI for prostate cancer?	1	4	2	2	3	3
My PSMA PET scan was negative. Should I repeat the test with another PET radiotracer or another scanner?	2	4	2	4	3	3
My PSMA PET scan was negative. When should I repeat the test?	2	4	2	4	4	3
Are there differences between PYLARIFY, ILLUCCIX, LOCAMETZ, POSLUMA, RADELUMIN, the radiotracers used for imaging prostate cancer?	0	1	2	0	1	1
Do I need to get a PET/CT if my PSA is rising after radiation therapy?	3	4	2	2	3	2
I had prostatectomy two years ago and my PSA is rising. I had a negative bone scan last week. What should I do next?	3	4	0	1	1	1
My Axumin PET scan was negative. What should I do next?	3	4	2	2	2	2
What is RADELUMIN?	1	1	1	2	3	3
What is POSLUMA?	1	1	1	3	3	3
What is LOCAMET2?	1	1	1	3	3	4
What is ILLUCCIX?	1	1	1	3	3	3
What is PYLARIFY?	1	1	2	2	3	3
Can I start hormonal therapy before a PSMA PET scan?	1	4	0	0	3	4
I had a prostatectomy 2 years ago, now my PSA is rising. what does it mean?	4	4	4	1	3	4

Table 2: Accuracy of Responses Provided by ChatGPT and Google Bard to Questions regarding Therapeutic Applications of PSMA PET/CT

	ChatGPT			Google Bard		
Questions	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 1	Reviewer 2	Reviewer 3
Is Pluvicto approved by the U.S. Food and Drug Administration?	1	1	1	4	3	4
Is radioligand therapy for prostate cancer approved by the U.S. Food and Drug Administration?	3	2	4	3	3	4
What is Pluvicto approved for?	1	1	1	2	4	3
Will my health insurance pay for Pluvicto therapy?	2	2	2	3	3	3
What is Pluvicto?	1	1	1	4	4	4
What is theranostics?	4	4	4	1	3	4
Where can I get Pluvicto therapy?	1	1	1	2	3	4
What doctor performs radioligand therapy for prostate cancer?	2	4	4	3	2	2
What data supports the radioligand therapy for prostate cancer?	2	2	2	1	1	2
What are the side-effects of Pluvicto?	1	1	1	2	3	4
What are the side effects of radioligand therapy for prostate cancer?	1	2	2	4	4	4
What can I do to minimize radiation exposure to my family after radioligand therapy for prostate cancer?	2	4	3	4	2	4
Do I need to undergo PSMA PET/CT before radioligand therapy?	2	2	1	4	2	1
I have a low blood count. Can I get radioligand therapy for prostate cancer?	2	2	2	4	3	3
Can I drive after receiving radioligand therapy for prostate cancer?	2	2	1	2	3	2
Can I travel after receiving radioligand therapy for prostate cancer?	1	2	1	1	3	1
Who is eligible for radioligand therapy for prostate cancer?	2	3	2	2	2	4
How do I know radioligand therapy for prostate cancer is working?	3	2	2	1	2	4
I have bad kidneys. Can I get radioligand therapy for prostate cancer?	3	4	2	2	2	3
Is radioligand therapy for prostate cancer performed as an outpatient procedure?	2	3	2	4	2	4
How often does PSA decrease after radioligand therapy for prostate cancer?	2	2	1	3	3	2
What are the differences between Xofigo and PSMA therapy?	3	2	2	1	3	3
Can I receive PSMA therapy after Xofigo?	4	2	1	3	3	4
Should I stop chemotherapy before PSMA therapy?	2	2	1	2	2	1
Can I receive hormonal therapy and PSMA therapy concurrently?	2	2	2	2	2	2
Can I receive Enzalutamide and PSMA therapy concurrently?	2	2	2	2	3	2
How long does radioligand therapy effect last?	1	2	1	1	3	2
Can I have sex after radioligand therapy?	1	2	1	1	1	1
How long will I be radioactive after Pluvicto therapy?	2	2	2	1	1	2
I have a caregiver. Can I get radioligand therapy for prostate cancer?	3	2	1	1	1	2
I am incontinent. Can I get radioligand therapy?	2	2	0	4	2	2
Do I need to undergo additional tests besides PSMA PET/CT before radioligand therapy?	1	2	1	4	1	3
How often PSA will decrease after Pluvicto therapy?	2	2	1	4	1	3
Do I need to stay in the hospital after PSMA therapy?	3	2	2	1	1	1
Is Pluvicto therapy dangerous?	3	2	3	3	2	2

RESULTS (Continued)

Table 3: Accuracy by Majority Vote

Questions	LLM	Correct Percentage (95% CI)	Partially correct Percentage (95% CI)	Incorrect Percentage (95% CI)
Diagnostic	ChatGPT	37% (21-55%)	33% (18-52%)	30% (16-49%)
	Google Bard	33% (19-52%)	43% (27-61%)	23% (11-42%)
Therapeutic	ChatGPT	14% (6-31%)	48% (32-65%)	37% (22-54%)
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- Google Bard was more likely to provide correct or partially correct answers to the therapeutic questions when compared to ChatGPT (odds ratio = 4.2, 95% CI: 2.2-7.7, $p < 0.005$). No statistically significant difference were identified between Google Bard and ChatGPT responses to diagnostic questions. Less than 5% of answers were scored as misleading (confabulation).

DISCUSSION

- ChatGPT and Google Bard were able to provide accurate responses (correct and partially correct) to the majority of non-expert questions related to diagnostic and therapeutic applications of PSMA with accuracy ranging 63-77%.
- There was no significant difference between ChatGPT and Google Bard in the accuracy of answers to diagnostic questions; however, Google Bard was more likely to provide accurate answers to the therapeutic questions when compared to ChatGPT.

REFERENCES

1. ChatGPT-3.5. OpenAI. https://openai.com/blog/chatgpt.
2. Google Bard. https://bard.google.com.

Comparative analysis of large language models: ChatGPT and Google Bard answer non-expert questions related to the diagnostic and therapeutic applications of prostate-specific membrane antigen (PSMA) in patients with prostate cancer

Julie Hong, Jeremie Calais, Matthias Benz, Martin Auerbach and Ali Salavati

Journal of Nuclear Medicine June 2024, 65 (supplement 2) 242416;

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Julie Hong, Jeremie Calais, Matthias

Journal of Nuclear Medicine June 2024, 6

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Is PSMA Imaging approved by the U.S. Food and Drug Administration?	1	2	2	1	3	4
What is PSMA Imaging approved for?	1	2	2	3	4	3
Will my health insurance pay for a PSMA PET/CT?	3	3	2	1	4	4
Is radiation from PSMA PET/CT dangerous?	4	4	2	1	3	2
What are the side-effects of PSMA PET/CT?	4	3	2	1	2	2
How accurate is PSMA PET/CT in finding prostate cancer?	4	4	2	1	3	4
My radiology report says "my tumor shows PSMA uptake." What does it mean?	2	4	2	4	4	4
Can I get screened for prostate cancer using PSMA PET/CT?	3	4	3	1	1	1
Do I need to get a PET/CT if my biopsy shows prostate cancer?	3	4	2	1	4	2
Do I need to get a PET/CT if my prostate MRI shows a suspicious finding?	3	4	2	4	4	2
Do I need to get a PSMA PET/CT if my PSA is rising after prostatectomy?	2	4	0	4	4	2
Are there different PET radiotracers for imaging prostate cancer?	1	3	2	2	1	2
What are the minimum PSA levels I should have to do a PET/CT scan?	2	4	2	1	1	2
What are the differences between PSMA PET/CT and Axumin PET/CT?	1	4	4	1	2	2
What are the differences between PET/CT and PET/MRI?	2	4	2	2	3	2
Which one is better PET/CT or PET/MRI for prostate cancer?	1	4	2	2	3	3
My PSMA PET scan was negative. Should I repeat the test with another PET radiotracer or another scanner?	2	4	2	4	3	3
My PSMA PET scan was negative. When should I repeat the test?	2	4	2	4	4	3
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Do I need to get a PET/CT if my PSA is rising after radiation therapy?	3	4	2	2	3	2
I had prostatectomy two years ago and my PSA is rising. I had a negative bone scan last week. What should I do next?	3	4	0	1	1	1
My Axumin PET scan was negative. What should I do next?	3	4	2	2	2	2
What is RADELUMIN?	1	1	1	2	3	3
What is POSLUMA?	1	1	1	3	3	3
What is LOCAMETZ?	1	1	1	3	3	4
What is ILLUCCIX?	1	1	1	3	3	3
What is PYLARIFY?	1	1	2	2	3	3
Can I start hormonal therapy before a PSMA PET scan?	1	4	0	0	3	4
I had a prostatectomy 2 years ago, now my PSA is rising. what does it mean?	4	4	4	1	3	4

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Julie Hong, Jeremie Calais, Matthias Ben

Journal of Nuclear Medicine June 2024, 65 (sup

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Will my health insurance pay for Pluvicto therapy?	2	2	2	3	3	3
What is Pluvicto?	1	1	1	4	4	4
What is theranostics?	4	4	4	1	3	4
Where can I get Pluvicto therapy?	1	1	1	2	3	4
What doctor performs radioligand therapy for prostate cancer?	2	4	4	3	2	2
What data supports the radioligand therapy for prostate cancer?	2	2	2	1	1	2
What are the side-effects of Pluvicto?	1	1	1	2	3	4
What are the side effects of radioligand therapy for prostate cancer?	1	2	2	4	4	4
What can I do to minimize radiation exposure to my family after radioligand therapy for prostate cancer?	2	4	3	4	2	4
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University of Massachusetts Amherst

Deep Learning for ^{177}Lu-PSMA Dose Prediction from Pre-Therapeutic ^{68}Ga-PSMA PET/CT Radiomics Features

Vibha Balaji[1], Bowen Lei[1], Fan Yang[1], Jie Luo[2], Pedram Heidari[2], Quanzheng Li[2], Joyita Dutta[1]

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Introduction

Background:

- Radiopharmaceutical Therapy (RPT) has emerged as a promising treatment for metastatic castration-resistant prostate cancer, leveraging the protein prostate-specific membrane antigen (PSMA) that is highly expressed on prostate cancer cells.
- PSMA radiolabeled with ^{177}Lu is ideal for diagnostic and therapeutic interventions using SPECT/CT.
- In clinical practice, patients undergo a pre-treatment PET/CT scan using the analogous radiotracer ^{68}Ga-PSMA to assess the distribution of PSMA in tumors and organs-at-risk (OARs) to gauge the responsiveness of the patient to PSMA RPT. This RPT workflow is illustrated in Fig. 1.
- Dosimetry involves calculating the time-integrated activity (TIA) and dose from multiple SPECT/CT timepoints.

Challenge:

- Current RPT protocols employ a fixed injected activity of 7.4 GBq for all patients.
- This protocol lacks customization based on individual variations in PSMA uptake from PET/CT scans as well as clinical bloodwork data, another source of inter-patient variability.

Objective:

- Explore the untapped potential of pre-therapy PET/CT scans for predicting 177Lu-PSMA dosimetry.
- Use AI models that forecast TIA and dose distribution across OARs using radiomic features extracted from PET/CT and clinical bloodwork data to demonstrate the need for personalized treatment regimens to optimize therapeutic efficacy and minimize risk to OARs.

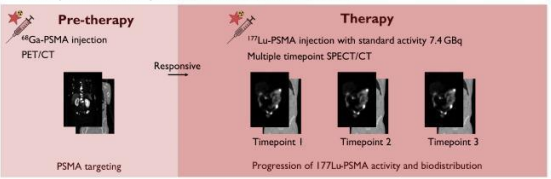

Fig. 1: Current ^{177}Lu-PSMA RPT clinical protocol.

Methods

Data Processing:

- Our dataset consists of pre-therapy PET/CT scan and 2 to 3 timepoint SPECT/CT scans of 19 patients undergoing ^{177}Lu-PSMA RPT.
- Image registration aligns PET to CT and each SPECT to the first timepoint CT. Automatic segmentation identifies 8 OARs in the CT images relevant to PSMA-RPT.
- PyRadiomics extracts 36 radiomic features (Intensity: 18, SUV: 4, Shape: 14) for each OAR, supplemented with clinical bloodwork data.
- The trapezoid method fits the time-activity curve (TAC) for the SPECT/CT timepoints on a voxel-level, estimating TIA by calculating the area under the TAC.
- Dose is estimated using S-values kernel specific to ^{177}Lu, convolved over the TIA map. This methodology is illustrated in Fig. 2.

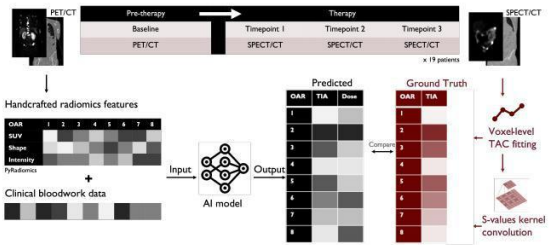

Fig. 2: Methodology of ^{177}Lu-PSMA RPT TIA and dose forecasting using radiomic features from pre-therapy PET/CT and clinical bloodwork data.

Model Training:

- The radiomics features and clinical bloodwork are passed through principal component analysis (PCA) to reduce the feature size.
- The following models are used
  - Linear Regression (baseline)
  - Support Vector Regression (SVR)
  - Decision Tree
  - Random Forest
  - Fully Connected Neural Network (FCNN)
- The output TIA and dose for each OAR is compared to the ground truth using mean squared error (MSE).

Results

- The dosimetry forecasting accuracy for the 5 models is calculated using MSE on the testing set for 8 OARs as well as the mean MSE over all OARs as shown in Table. 1.
- The AI models show good predictive capabilities in most of the OARs.
- In specific, the FCNN shows good ability to predict the TIA and dose in 5 out of 8 OARs and best overall performance.

OAR	Linear		SVR		Decision Tree		Random Forest		FCNN		OAR Mean	
	TIA	Dose	TIA	Dose	TIA	Dose	TIA	Dose	TIA	Dose	TIA	Dose
Spleen	0.208	0.425	0.199	0.397	2.283	3.592	0.252	0.400	**0.113**	0.053	0.611	0.973
Right Kidney	0.624	0.986	0.718	0.752	2.332	1.623	0.519	0.957	**0.022**	0.327	0.843	0.929
Left Kidney	4.039	3.960	4.336	5.076	1.657	2.454	0.922	1.378	**0.224**	0.752	2.236	2.724
Gallbladder	1.781	1.278	2.456	1.341	5.589	1.117	1.420	0.496	**0.036**	0.120	2.256	0.870
Liver	0.917	0.737	0.858	0.848	2.970	3.087	0.620	0.659	**0.327**	0.202	1.139	1.107
Stomach	1.398	2.478	0959	0.987	0.319	0.479	0.395	0.477	**0.263**	0.356	0.665	0.955
Pancreas	2.724	2.099	2.244	1.860	0.696	0.658	0.386	0.103	**0.167**	0.002	1.243	0.944
Prostate	1.139	1.635	0.903	1.598	0.125	0.281	0.256	0.423	**0.082**	0.224	0.501	0.832
Model Mean	1.603	1.700	1.584	1.607	1.996	1.661	0.596	0.612	**0.154**	0.254	1.187	1.167

Table. 1: Demonstration of the TIA and dose forecasting capability of 5 over 8 OARs. In **bold** is the best predicting model for that OAR.

Conclusions

- We demonstrated the potential of using pre-therapy PET/CT scans to forecast dosimetry of 177Lu-PSMA RPT using AI models over 8 OARs.
- As future work, perform analysis using multiple OARs to identify cross-OAR interactions.
- We also aim to implement voxel-level forecasting to improve the spatial resolution of our analysis.

References

[1] Peters SMB, Hofferber R, Privé BM, et al. [68Ga]Ga-PSMA-11 PET imaging as a predictor for absorbed doses in organs at risk and small lesions in [177Lu]Lu-PSMA-617 treatment. *Eur J Nucl Med Mol Imaging*. 2022;49:1101-1112.

[2] 1. Sartor O, de Bono J, Chi KN, et al. Lutetium-177–PSMA-617 for Metastatic Castration-Resistant Prostate Cancer. *N Engl J Med*. 2021;385:1091-1103.

Acknowledgment

- This work was supported by the Institute of Applied Life Sciences (IALS) Translation Graduate Student Fellowship at the University of Massachusetts Amherst.

Deep learning for 177Lu-PSMA dose prediction from pre-therapeutic 68Ga-PSMA PET/CT radiomics features

Vibha Balaji, Fan Yang, Bowen Lei, Jie Luo, Pedram Heidari, Quanzheng Li and Joyita Dutta

Journal of Nuclear Medicine June 2024, 65 (supplement 2) 242200;

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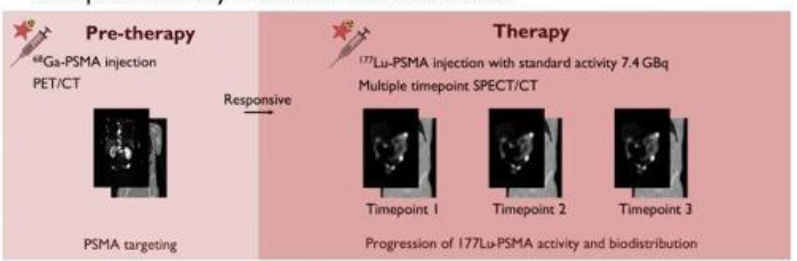

Fig. 1: Current ^{177}Lu-PSMA RPT clinical protocol.

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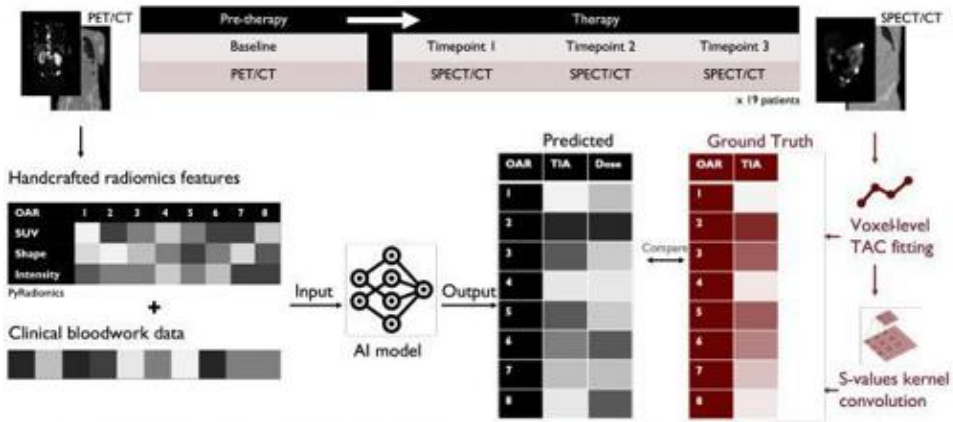

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Volumetric assessment of body composition from cardiac SPECT CT attenuation maps and association of sarcopenia measures with mortality

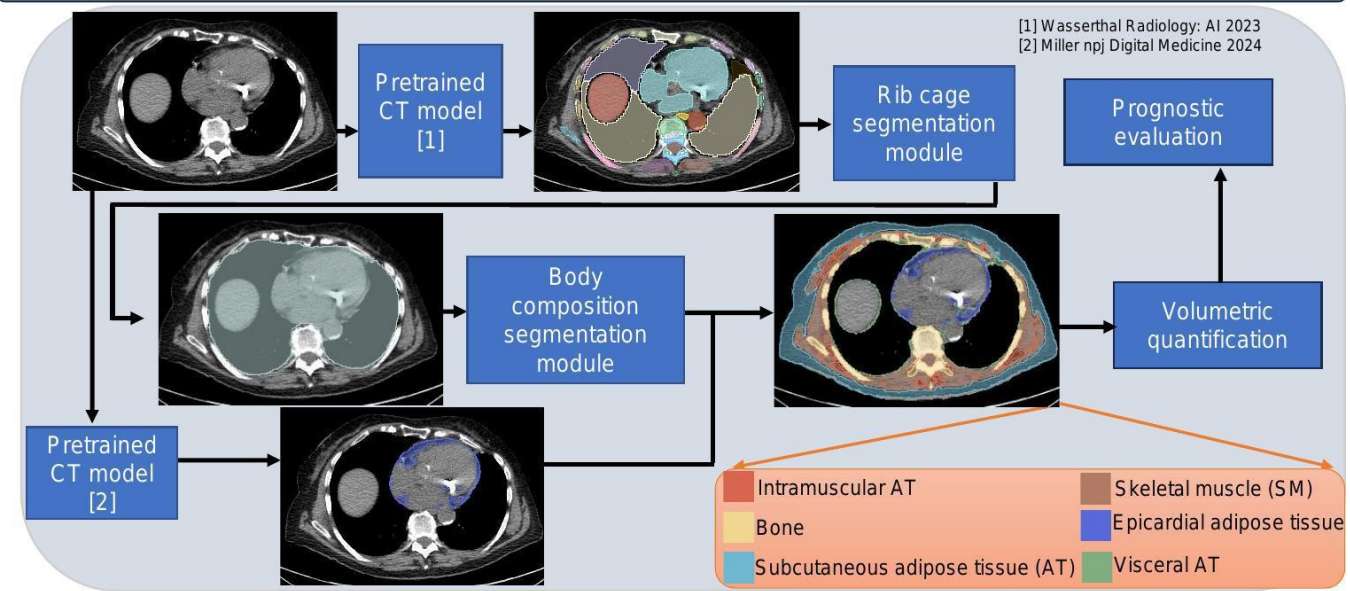
Jirong Yi, PhD[a] Anna M. Michalowska, MD,PhD[a,b] Aakash Shanbhag, MSc[a,c] Robert J. Miller, MD[a,d] Jolien Geers, MD[a,e] Wenhao Zhang, PhD[a] Aditya Killekar, MSc[a] Nipun Manral, MSc[a] Mark Lemley, BSc[a] Jianhang Zhou, MSc[a] Joanna X. Liang, MPH[a] Valerie Builoff, BSc[a] Terrence D. Ruddy, MD[f] Andrew J. Einstein, MD,PhD[g] Attila Feher, MD,PhD[h] Edward J. Miller, MD,PhD[h] Albert J. Sinusas, MD,PhD[h] Mikolaj Buchwald, PhD[a] Jacek Kwiecinski, MD,PhD[i] Paul B. Kavanagh, MSc[a] Damini Dey, PhD[a] Daniel S. Berman, MD[a] Piotr J. Slomka, PhD[a]

[a] Cedars-Sinai Medical Center, USA [b] National Medical Institute of the Ministry of the Interior and Administration, Poland [c] University of Southern California, USA [d] University of Calgary, Calgary, Canada [e] Vrije Universiteit Brussel (VUB), Belgium [f] University of Ottawa Heart Institute, Canada [g] Columbia University Irving Medical Center and New York-Presbyterian Hospital, USA [h] Yale University School of Medicine, United States [i] Institute of Cardiology, Poland

Background and Purpose

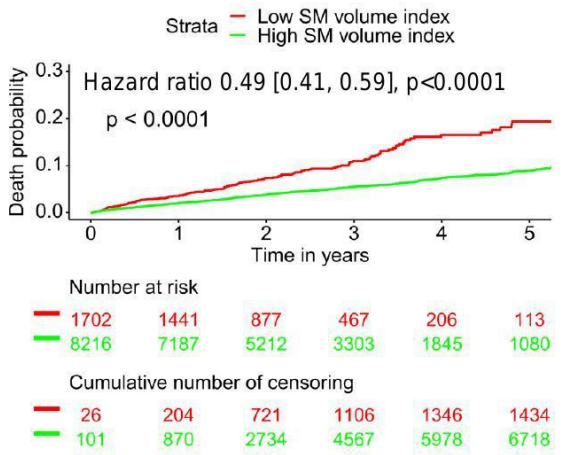
- Prognostic evaluation of volumetric body composition from computed tomography for SPECT attenuation correction (CTAC) scan has not been studied
- Aim 1: develop and validate an annotation-free method for body composition segmentation
- Aim 2: evaluate the prognostic value for sarcopenia measurements to predict all-cause mortality (ACM)

Methods



- Skeletal muscle (SM) cutoff: 597.16 cm^3/m^2
- Cox proportional hazard model for hazard ratios (HRs) calculation
- Log-rank test for evaluating statistical significance

Results



SNMMI 2024 ABSTRACT #: 2167 [Yi et al., SNMMI 2024]

Conclusions

- Fully automated volumetric body composition quantification from CTAC is feasible
- Volumetric body composition quantification is strongly associated with all-cause mortality

Disclosures

Disclosures This research was supported in part by Grants R01HL089765 and R35HL161195 from the National Heart, Lung, and Blood Institute/National Institutes of Health (NHLBI/NIH) (PI: Piotr Slomka).

Slomka Laboratory, Cedars-Sinai Medical Center

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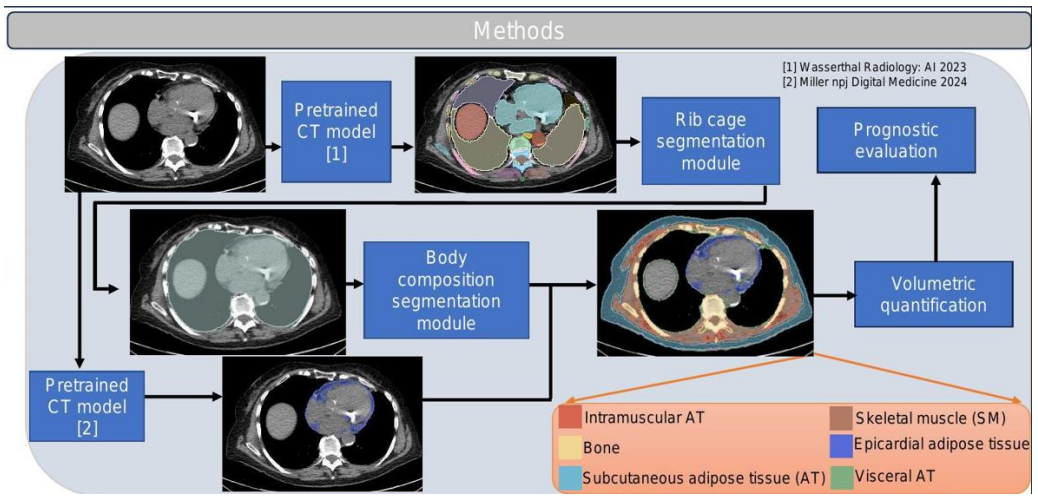
Journal of Nuclear Medicine June 2024, 65 (supplement 2) 242167;

La sarcopénie est définie par une perte progressive et généralisée de la masse, de la force et de la qualité de l'ensemble de la musculature dès l'âge de 50 ans, pouvant conduire à terme, à une diminution supérieure à 30% de la masse musculaire initiale. Ses conséquences sont nombreuses : augmentation du risque de chutes (première cause de décès liée à une blessure chez les plus de 65 ans), augmentation de la durée d'hospitalisation, des risques infectieux, de la dépendance des personnes touchées… Qualifiée de « maladie » en 2016 par l'Organisation Mondiale de la Santé, la sarcopénie, touche actuellement environ un Européen sur cinq de plus de 55 ans (30 millions d'ici 2045) : c'est un réel enjeu de santé publique.

Introduction: Sarcopenia is well-established as an important clinical factor, and its quantification is typically performed using L3 slice from abdominal CT. We developed a novel method combining artificial intelligence (AI) and image processing to automatically and volumetrically analyze its quantification from SPECT/CT attenuation maps (CTAC). We aimed to evaluate the prognostic value for sarcopenia measurements to predict all-cause mortality (ACM) during follow-up.

Methods: The study involved 10826 patients [male 5989 (55.32%)] from the multicenter REFINE SPECT registry from 4 different institutes with available cardiac SPECT/CT scans [kVp 120-130] with over 2-year follow-up for mortality. We utilized a previously validated deep learning CT segmentation model (TotalSegmentor v2) combined with image processing steps to automatically outline the rib cage which surrounds the lungs and the heart, then threshold fat and muscle within these structures (Hounsfield Unit [HU] [-29, 150] for skeletal muscle (SM), and [-190,-30] for adipose tissue), and segment 5 body tissues (SM, bone, subcutaneous adipose tissue (SAT), intramuscular adipose tissue (IMAT), and visceral adipose tissue (VAT)) on CTAC. We then evaluated the prognostic value of SM indexed volume (SM volume/height^2 [cm^3/m^2]). We applied a percentile-based grid search to establish sex-specific thresholds for risk stratification for the proposed SM measure. Kaplan-Meier curves and unadjusted Cox proportional hazard ratios (HRs) were used to evaluate associations with ACM. The log-rank test was used to evaluate statistical significance.



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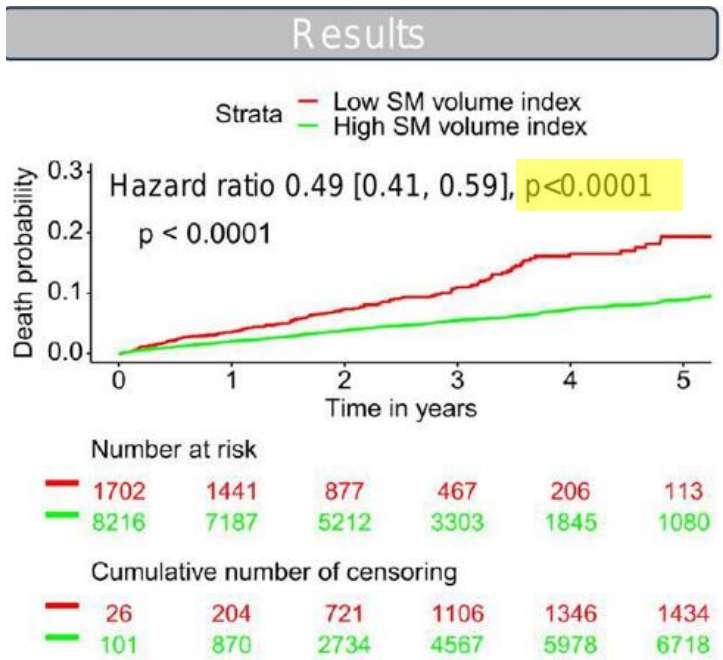

Results: The age (median, Interquartile range [IQR]) was 65 [57-73] years. During a follow-up of 870 [522-1296] days, 667 (6.2%) patients died. Total computing was 110 seconds per case (64 sec for deep learning segmentation NVIDIA RTX Titan GPU for and 46 sec for image processing with AMD 3960X CPU). The indexed volumes in population (median [IQR] in cm^3/m^2) were 1005.8

- Skeletal muscle (SM) cutoff: 597.16 cm^3/m^2

Conclusions: Automatic volumetric body composition including sarcopenia measures can be obtained from cardiac SPECT/CT attenuation maps. Chest skeletal muscle characteristics improve mortality risk assessment in cardiovascular patients undergoing myocardial perfusion imaging, without additional scanning or physician interaction.

The importance of healthy organ radiomics in overall survival prediction of NSCLC patients in PET/CT images: Toward digital twins

Yazdan Salimi, Ghasem Hajianfar, Zahra Mansouri, Amirhossein Sanaat, Mehdi Amini, Isaac Shiri and Habib Zaidi

Journal of Nuclear Medicine June 2024, 65 (supplement 2) 241748;

Introduction: Radiomics/dosiomics analysis coupled with machine learning (ML) algorithms have shown promising results for prognosis and outcome prediction. However, most studies focus on radiomics/dosiomics features extracted from the tumoral volume, while the overall patient's conditions may have a role in monitoring survival and response to treatment. In this study, we evaluated the value of radiomic features extracted from healthy tissues, including 26 organs added to radiomics features extracted from the gross tumor volume (GTV) delineated on PET/CT images, in the context of survival prediction of NSCLC patients.

The importance of healthy organ radiomics in overall survival prediction of NSCLC patients in PET/CT images: Toward digital twins

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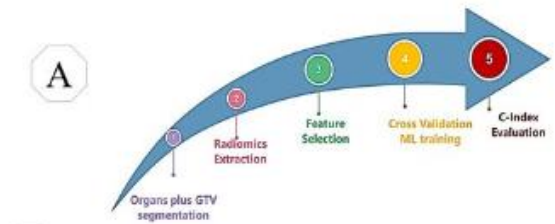
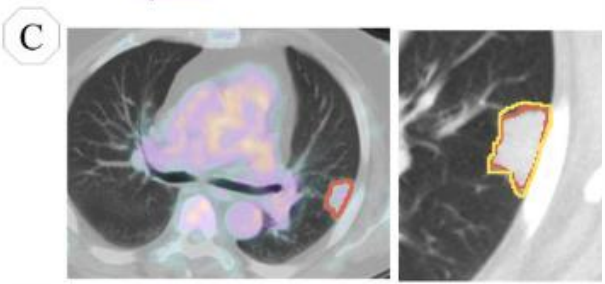
Methods: We used 151 PET/CT images with follow up and survival status from radiogenomics dataset downloaded from TCIA archive. We used updated versions of pretrained deep learning-based segmentation model developed by our group (1) using nnUnet (2) pipeline. We segmented 26 organs including 5 bony structures and 21 soft tissues. We trained a DL segmentation network using nnUnet pipeline to segment lung lesions (GTV) using LIDC dataset as train dataset (3). Subsequently, 107 radiomic features, including first-order, shape and texture features extracted from each organ plus GTV defined on the lung lesion from CT and PET images using PyRadiomics library (converted to SUV). These features were fed to a Univariate Concordance Index (UCI) feature selection algorithm and a random survival forest (RSF) ML algorithm using three-fold nested cross-validation strategy. We used nine combinations of organs, GTV, CT and PET features shown in figure 1C. The model performance was calculated in terms of C_Index. Figure 1A summarizes the steps followed in this study.





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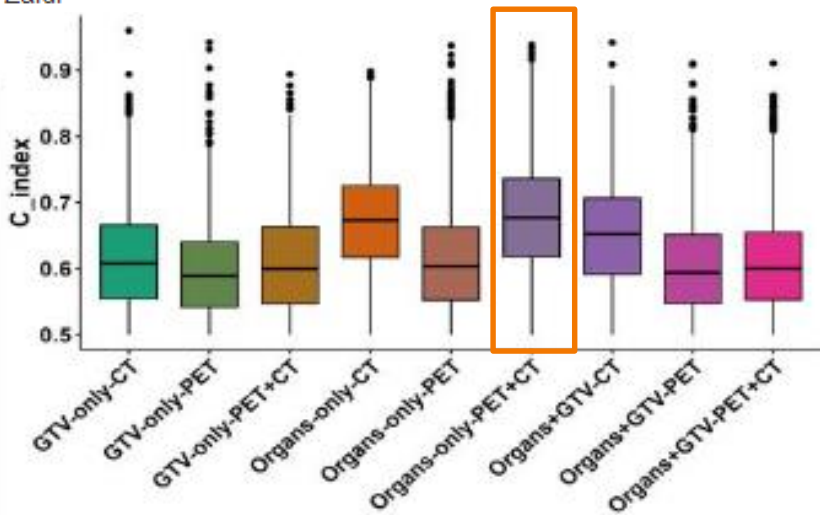
Results: Figure 1B shows an example of deep learning-assisted segmentation output on a total body CT image. Figure 1C (left panel) shows an example of fused PET/CT image segmented by our model whereas figure 1C (right panel) shows the excellent match between the ground truth segmentation (red) and output of our deep learning model (yellow) on a diagnostic CT image at corresponding slice. The most frequently reported radiomic features were selected from lungs, aorta, heart, and kidney segmentations, in addition to GTV. Figure 1D shows the boxplot comparing the C-Indices among every nine-input data. Figure 1E indicates that organ features from both PET and CT images was the best performance model with C-Index of 0.68. Organs radiomic features derived from CT images was the next best model with C-Index of 0.67. Using only GTV radiomics from CT, PET, and both images achieved C-Indices of 0.62, 0.60, and 0.61 respectively.



	C-Index			
Input	Fold1	Fold2	Fold3	Overall
GTV-only-CT	0.6 ± 0.074	0.66 ± 0.066	0.59 ± 0.068	0.62 ± 0.075
GTV-only-PET	0.6 ± 0.074	0.62 ± 0.062	0.57 ± 0.055	0.6 ± 0.068
GTV-only-PET+CT	0.59 ± 0.07	0.66 ± 0.062	0.57 ± 0.057	0.61 ± 0.074
Organs-only-CT	0.68 ± 0.077	0.7 ± 0.062	0.63 ± 0.073	0.67 ± 0.077
Organs-only-PET	0.65 ± 0.089	0.61 ± 0.063	0.58 ± 0.061	0.61 ± 0.077
Organs-only-PET+CT	0.71 ± 0.089	0.62 ± 0.066	0.7 ± 0.069	0.68 ± 0.085
Organs+GTV-CT	0.65 ± 0.074	0.7 ± 0.063	0.6 ± 0.065	0.65 ± 0.079
Organs+GTV-PET	0.64 ± 0.075	0.61 ± 0.062	0.56 ± 0.044	0.6 ± 0.07
Organs+GTV-PET+CT	0.61 ± 0.077	0.62 ± 0.064	0.6 ± 0.067	0.61 ± 0.07

The importance of healthy organ radiomics in overall survival prediction of NSCLC patients in PET/CT images: Toward digital twins

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Conclusions: We evaluated the prognostic value of radiomic features from different healthy organs and GTV segmentation in a machine learning pipeline. We followed standard and same feature extraction, feature selection and machine learning pipeline for these regions of interest. Surprisingly, the importance of healthy organs radiomics was more relevant than GTV. Our results revealed the importance of overall patient health conditions which may be hidden in healthy organ radiomics in overall survival prediction. Although, these findings need to be verified in other tasks and other datasets, we suggest considering healthy organs radiomics in prognostic models to be one step closer to using all patient information towards digital twins framework in medical imaging.

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Organomics

A Concept Reflecting the Importance of PET/CT Healthy Organ Radiomics in Non–Small Cell Lung Cancer Prognosis Prediction Using Machine Learning

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TABLE 5. Model Performance Comparison Based on Inputs in Terms of 3-Fold Average C-index

	#	Inputs	C-index (Average Over All Folds) Mean	Std	Minimum	Maximum
Clinical Only	1	Clinical	0.58	0.02	0.52	0.61
GTV Only	2	PET GTV	0.59	0.02	0.55	0.63
	3	CT GTV	0.59	0.02	0.55	0.62
	4	PET GTV + CT GTV	0.59	0.02	0.55	0.63
	5	PET GTV + Clinical	0.60	0.03	0.53	0.65
	6	CT GTV + Clinical	0.59	0.02	0.54	0.63
	7	PET GTV + CT GTV + Clinical	0.60	0.02	0.53	0.63
Organomics Only	8	PET Organomics	0.61	0.03	0.57	**0.68**
	9	CT Organomics	0.61	0.02	0.55	**0.67**
	10	CT Organomics + PET Organomics	0.60	0.03	0.52	**0.68**
	11	PET Organomics + Clinical	0.60	0.02	0.57	0.65
	12	CT Organomics + Clinical	0.60	0.02	0.57	0.63
	13	PET Organomics + CT Organomics + Clinical	0.60	0.02	0.55	0.63
Single Modalities	14	PET GTV + PET Organomics	0.61	0.02	0.57	0.66
	15	CT GTV + CT Organomics	0.60	0.02	0.56	0.65
	16	PET GTV + PET Organomics + Clinical	0.60	0.03	0.54	0.66
	17	CT GTV + CT Organomics + Clinical	0.59	0.02	0.52	0.62
	18	PET Organomics + CT Organomics + PET GTV + CT GTV	0.59	0.02	0.55	**0.67**
All included	19	PET Organomics + CT Organomics + PET GTV + CT GTV + Clinical	0.60	0.02	0.55	0.65

The highest values of 0.68 and 0.67 achieved are highlighted with bold font.

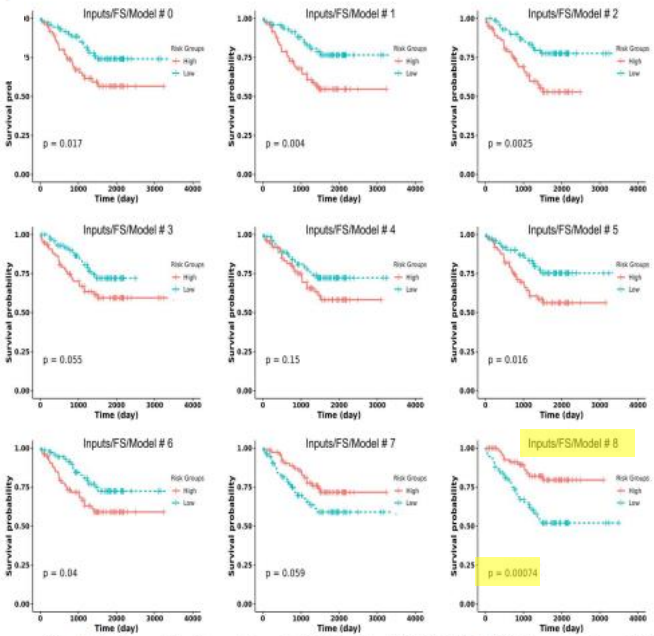

FIGURE 5. KM curves of 9 selected combinations of Inputs/FS/Model. #0: PET GTV + PET Organomics + Clinical/UCI/RSF, #1: PET Organomics + CT Organomics + PET GTV + CT GTV + Clinical/UCI/RSF, #2: CT Organomics/UCI/RSF, #3: CT Organomics/MI/RSF, #4: PET Organomics/MD/Coxph, #5: CT Organomics + PET Organomics/UCI/glmnet, #6: CT GTV + CT Organomics/UCI/RSF, #7: CT Organomics + PET Organomics/VH/Coxph, #8: PET Organomics + CT Organomics + PET GTV + CT GTV/MD/RSF. *P* values shown in the bottom of each curve. *P* values <0.05 are considered statistically significant.