



Cancer du poumon

Objectifs

- Identifier de nouveaux biomarqueurs pronostiques et/ou prédictifs chez les patients atteints d'un cancer pulmonaire en imagerie TEP et TDM
- Combiner des informations radiomiques, cliniques et/ou biologiques pour développer des modèles applicables en clinique

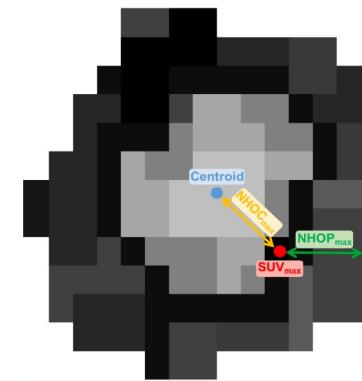
Originalités

- Accès aux bases de données de l’Institut Curie/Institut du Thorax Curie-Montsouris : nouvelles thérapies, suivi des patients, multimodalités...
- Stratégie de diffusion de biomarqueurs/modèles développés 
- Validation de biomarqueurs/modèles existants 

Illustration n°1 : nouveaux biomarqueurs en TEP – Narinée



Evaluer des nouveaux biomarqueurs en imagerie TEP



> Proc Natl Acad Sci U S A. 2021 Feb 9;118(6):e2018110118. doi: 10.1073/pnas.2018110118.

Evolutionary dynamics at the tumor edge reveal metabolic imaging biomarkers

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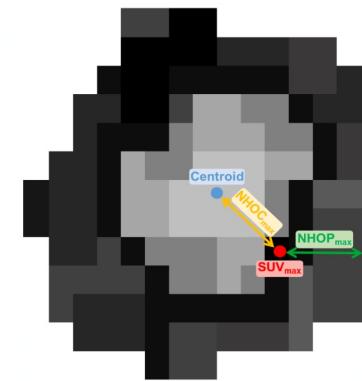
SUVmax to tumor perimeter distance: a robust radiomics prognostic biomarker in resectable non-small cell lung cancer patients

Germán Andrés Jiménez-Londono ¹, Ana María García Vicente ², Jesús J Bosque ³,
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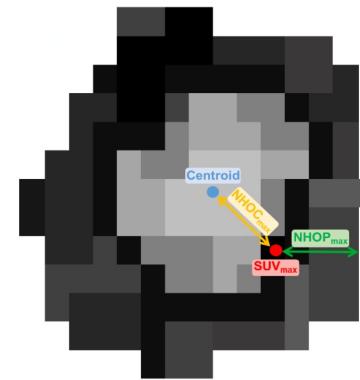


Images TEP au 18F-FDG pré-traitement, CPNPC

Cohorte 1 : 99 → étude technique

Cohorte 2 : 244 → analyse de survie

Données de suivi – Institut Curie



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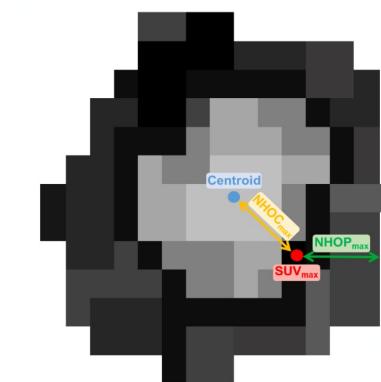
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	HighGrayZoneEmph	SUVmin	SUVmean	SUVpeak	NHOPeak	JoinEntropyLog10	MTV	TLG	LowGrayZoneEmph	InDiffoment	ShotRunEmph	LongRunEmph	Sphericity	NHOmax	NHOpeak
HighGrayZoneEmph	1.00	0.41	0.33	0.35			0.11	0.29	0.11				0.24		
SUVmin		1.00	0.72	0.55	0.55			0.15	0.28	0.01	0.23	0.32	0.34	0.36	
SUVmean	0.41	0.72	1.00	0.94	0.94			0.18	0.01		0.31	0.20	0.06	0.03	0.13
SUVmax	0.53	0.55	0.94	1.00	0.99	0.34	0.26	0.17	0.19	0.47	0.33	0.27	0.25	0.22	0.20
SUVpeak	0.33	0.55	0.94	0.99	1.00	0.10	0.21	0.25	0.25	0.52	0.36	0.31	0.29	0.27	0.20
NHOPeak						1.00	0.58	0.22	0.28	0.26	0.30	0.25	0.25	0.24	0.21
NHOPmax							0.19	0.26	0.21	0.50	1.00				0.43
NHOPpeak								0.11	0.20	0.27	0.19	0.13	0.13	0.22	0.45
JoinEntropyLog10							0.15	0.17	0.25	0.22	1.00	0.92	0.85	0.63	0.68
MTV	0.11	0.26	0.19	0.25	0.28	0.13		0.52	1.00	0.94	0.72	0.83	0.82	0.84	0.48
TLG			0.01	0.31	0.47	0.52	0.26	0.20	0.85	0.94	1.00	0.74	0.79	0.78	0.79
LowGrayZoneEmph	0.29	0.23	0.28	0.33	0.36	0.30	0.27	0.63	0.72	0.74	1.00	0.73	0.69	0.69	0.40
InDiffoment	0.11	0.32	0.01	0.27	0.31	0.25	0.15	0.68	0.83	0.79	0.73	1.00	0.94	0.94	0.40
ShotRunEmph		0.34	0.25	0.29	0.25	0.12	0.70	0.82	0.78	0.69	0.94	1.00	0.99	0.25	0.32
LongRunEmph			0.26	0.22	0.27	0.24	0.12	0.73	0.84	0.79	0.69	0.94	0.99	1.00	0.26
Sphericity	0.24		0.11	0.29	0.29	0.21	0.22	0.41	0.48	0.51	0.40	0.40	0.25	0.26	0.40
NHOmax				0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43	0.40	0.42	0.32	0.33
NHOpeak				0.12	0.21	0.35	0.34	0.35	0.39	0.49	0.57	0.60	0.53	0.59	0.49



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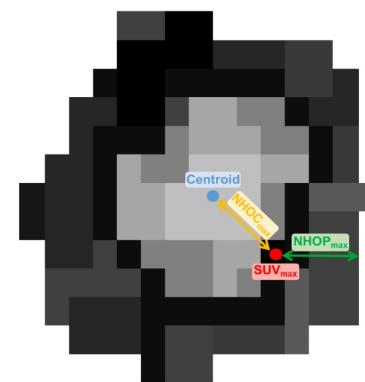
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	HighGrayZoneEmph	SUVmin	SUVmean	SUVpeak	NHOPeak	JoinEntropyLog10	MTV	TLG	LowGrayZoneEmph	InDiffoment	ShotRunEmph	LongRunEmph	Sphericity	NHOmax	NHOpeak
HighGrayZoneEmph	1.00	0.41	0.33	0.35											
SUVmin		1.00	0.72	0.55	0.55				0.15	0.28	0.01	0.23	0.32	0.34	0.36
SUVmean	0.41	0.72	1.00	0.94	0.94				0.18	0.01		0.31	0.20	0.06	0.13
SUVmax	0.53	0.55	0.94	1.00	0.99	0.34	0.26	0.17	0.19	0.47	0.33	0.27	0.25	0.22	0.20
SUVpeak	0.33	0.55	0.94	0.99	1.00	0.10	0.21	0.25	0.25	0.52	0.36	0.31	0.29	0.27	0.20
NHOPeak						1.00	0.58		0.22	0.28	0.26	0.30	0.25	0.25	0.24
NHOPpeak							0.19	0.26	0.21	0.59	1.00	0.11	0.20	0.27	0.19
JoinEntropyLog10							1.00	0.92	0.85	0.63	0.68	0.70	0.73	0.41	0.36
MTV	0.11	0.26	0.19	0.25	0.28	0.13		1.00	0.94	0.72	0.83	0.82	0.84	0.48	0.36
TLG			0.01	0.31	0.47	0.52	0.26		0.85	0.94	1.00	0.74	0.79	0.78	0.79
LowGrayZoneEmph	0.29	0.23	0.28	0.33	0.36	0.30	0.27	0.63	0.72	0.74	1.00	0.73	0.69	0.69	0.40
InDiffoment	0.11	0.32	0.01	0.27	0.31	0.25	0.15	0.68	0.83	0.79	0.73	1.00	0.94	0.94	0.40
ShotRunEmph		0.34	0.25	0.29	0.25	0.12	0.70	0.82	0.78	0.69	0.94	1.00	0.99	0.25	0.32
LongRunEmph	0.36		0.22	0.27	0.24	0.12	0.73	0.84	0.79	0.69	0.94	0.99	1.00	0.26	0.33
Sphericity	0.24		0.11	0.29	0.29	0.21	0.22	0.41	0.48	0.51	0.40	0.40	0.25	0.26	1.00
NHOmax				0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43	0.40	0.42	0.32	0.33
NHOpeak					0.12	0.21	0.35	0.34	0.35	0.39	0.49	0.57	0.60	0.53	0.59

complémentaire



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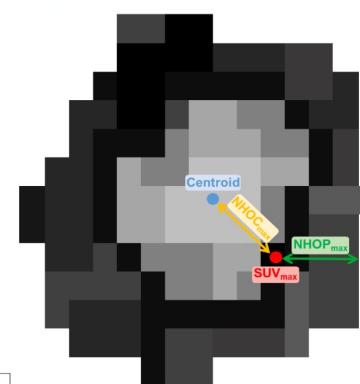
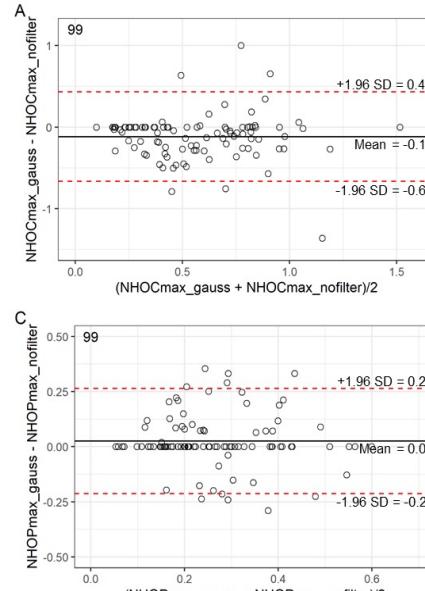
Cohorte 1 : 99 → étude technique

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Données de suivi – Institut Curie

	HighGrayZoneEmph	SUVmin	SUVmean	SUVpeak	NHOPeak	JoinEntropyLog10	MTV	TLG	LowGrayZoneEmph	InDiffoment	ShortRunEmph	LongRunEmph	Sphericity	NHOmax	NHOpeak
HighGrayZoneEmph	1.00	0.41	0.33	0.35											
SUVmin		1.00	0.72	0.55	0.55										
SUVmean	0.41		1.00	0.94	0.94										
SUVmax	0.53	0.55	0.94	1.00	0.99										
SUVpeak	0.33	0.55	0.94	0.99	1.00										
NHOPeak						1.00	0.50								
NHOPpeak							0.50	1.00							
JoinEntropyLog10								1.00	0.92	0.85	0.63	0.68	0.70	0.73	
MTV	0.11	0.26	0.19	0.25	0.28	0.13		0.52	1.00	0.94	0.72	0.83	0.82	0.84	
TLG								0.85	0.94	1.00	0.74	0.79	0.78	0.79	0.51
LowGrayZoneEmph	0.29	0.23	0.20	0.33	0.36	0.30	0.27	0.63	0.72	0.74	1.00	0.73	0.69	0.69	0.40
InDiffoment	0.11	0.32	0.06	0.27	0.31	0.25	0.15	0.68	0.83	0.79	0.73	1.00	0.94	0.94	0.40
ShortRunEmph								0.70	0.82	0.78	0.69	0.94	1.00	0.99	0.25
LongRunEmph	0.36		0.22	0.27	0.24	0.12		0.73	0.84	0.79	0.69	0.94	0.99	1.00	0.26
Sphericity	0.24		0.11	0.29	0.29	0.21		0.41	0.48	0.51	0.40	0.40	0.25	0.26	1.00
NHOmax								0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43
NHOpeak								0.32	0.21	0.35	0.34	0.35	0.39	0.49	0.57

complémentaire



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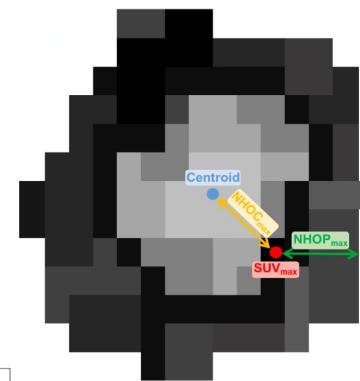
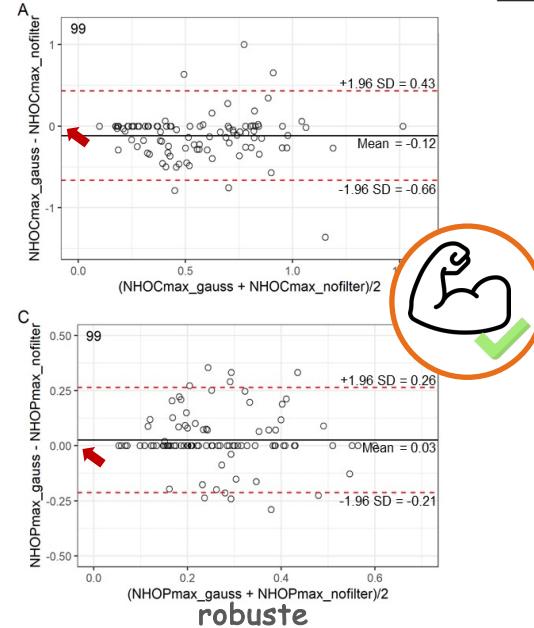
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SUVmean	0.41	0.72	1.00	0.94	0.94										
SUVmax	0.53	0.55	0.94	1.00	0.99										
SUVpeak	0.33	0.55	0.94	0.99	1.00										
NHOPeak						1.00	0.50								
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LongRunEmph	0.36	0.22	0.27	0.24	0.12	0.73	0.84	0.79	0.69	0.94	0.99	1.00	0.26	0.33	0.50
Sphericity	0.24	0.11	0.29	0.29	0.21	0.22	0.41	0.48	0.51	0.40	0.40	0.25	0.26	1.00	0.40
NHOmax			0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43	0.40	0.42	0.32	0.33	0.40
NHOpeak			0.32	0.21	0.35	0.34	0.35	0.39	0.49	0.57	0.60	0.53	0.59	0.49	0.50

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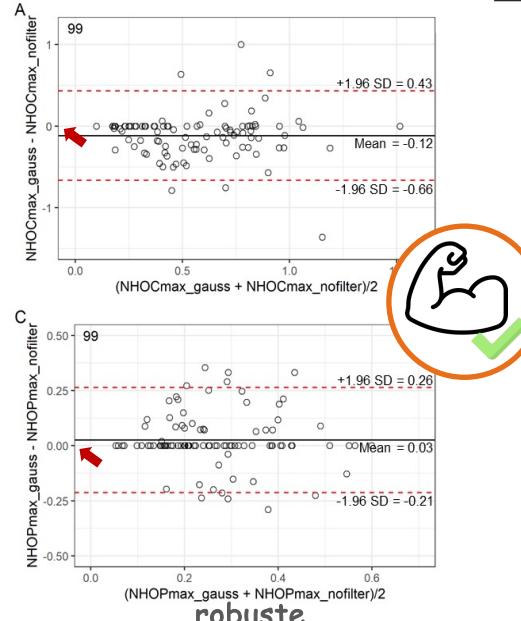
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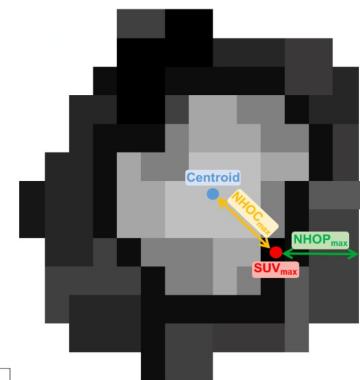
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HighGrayZoneEmph	1.00	0.41	0.33	0.35											
SUVmin		1.00	0.72	0.55	0.55										
SUVmean	0.41		1.00	0.94	0.94										
SUVmax	0.53	0.55	0.94	1.00	0.99										
SUVpeak	0.33	0.55	0.94	0.99	1.00										
NHOPeak						1.00	0.50								
NHOPpeak							1.00	0.50							
JointEntropyLog10							1.00	0.92	0.85	0.63	0.68	0.70	0.73		
MTV	0.11	0.26	0.19	0.25	0.28	0.13		1.00	0.90	0.83	0.82	0.84	0.48	0.36	
TLG							0.52	1.00	0.94	0.72	0.83	0.82	0.84		
LowGrayZoneEmph	0.29	0.23	0.20	0.33	0.36	0.30	0.27		1.00	0.74	0.79	0.78	0.79	0.51	0.43
InDiffoment	0.11	0.32	0.06	0.27	0.31	0.25	0.15	0.68		1.00	0.94	0.94	0.94	0.40	0.42
ShortRunEmph								0.83	0.79	0.73	1.00	0.94	0.94	0.40	0.42
LongRunEmph	0.36		0.22	0.27	0.24	0.12	0.73	0.84	0.79	0.69	0.94	0.99	1.00	0.26	0.33
Sphericity	0.24		0.13	0.29	0.29	0.21	0.22	0.41	0.48	0.51	0.40	0.40	0.25	0.26	1.00
NHOmax			0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43	0.40	0.42	0.32	0.33	0.40
NHOpeak			0.32	0.21	0.35	0.34	0.35	0.39	0.49	0.57	0.60	0.53	0.59	0.49	0.50

complémentaire



Team building – Thème 5 - 16-17 novembre 2023 | 11



> Proc Natl Acad Sci U S A. 2021 Feb 9;118(6):e2018110118. doi: 10.1073/pnas.2018110118.

Evolutionary dynamics at the tumor edge reveal metabolic imaging biomarkers

Juan Jiménez-Sánchez ¹, Jesús J Bosque ¹, Germán A Jiménez-Londroño ², David Molina-García ³, Álvaro Martínez ¹ ³, Julián Pérez-Beteta ³, Carmen Ortega-Sabater ¹, Antonio Francisco Honguero-Martínez ⁴, Víctor M Pérez-García ³, Ángel María Soriano-Castrén ²

> Eur Radiol. 2022 Jun;32(6):3889-3902. doi: 10.1007/s00330-021-08523-3. Epub 2022 Feb 8.

SUVmax to tumor perimeter distance: a robust radiomics prognostic biomarker in resectable non-small cell lung cancer patients

Germán Andrés Jiménez-Londroño ¹, Ana María García Vicente ², Jesús J Bosque ³, Mariano Amo-Salas ⁴, Julián Pérez-Beteta ³, Antonio Francisco Honguero-Martínez ⁵, Víctor M Pérez-García ³, Ángel María Soriano-Castrén ²

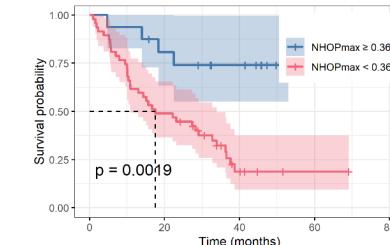
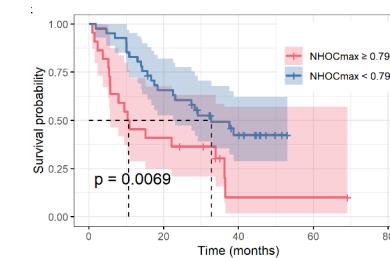


Illustration n°1 : nouveaux biomarqueurs en TEP – Narinée



Evaluer des nouveaux biomarqueurs en imagerie TEP



Images TEP au 18F-FDG pré-traitement, CPNPC

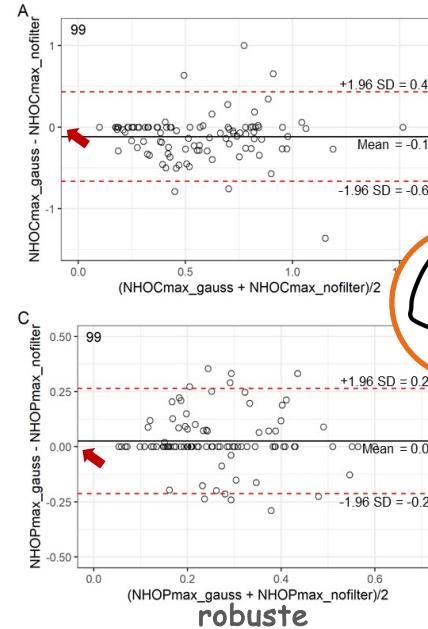
Cohorte 1 : 99 → étude technique

Cohorte 2 : 244 → analyse de survie

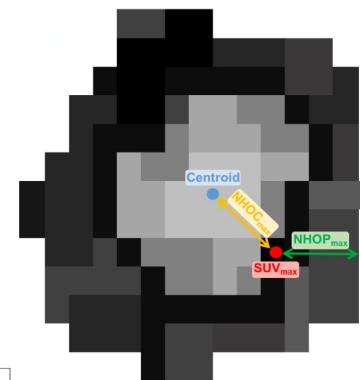
Données de suivi – Institut Curie

	HighGrayZoneEmph	SUVmin	SUVmean	SUVpeak	NHOPeak	JointEntropyLog10	MTV	TLG	LowGrayZoneEmph	InDiffoment	ShotRunEmph	LongRunEmph	Sphericity	NHOmax	NHOpeak
HighGrayZoneEmph	1.00	0.41	0.33	0.35											
SUVmin		1.00	0.72	0.55	0.55										
SUVmean	0.41		1.00	0.94	0.94										
SUVmax	0.53	0.55	0.94	1.00	0.99										
SUVpeak	0.33	0.55	0.94	0.99	1.00										
NHOPeak						1.00	0.50								
NHOPpeak								1.00	0.50						
JointEntropyLog10							1.00	0.92	0.85	0.63	0.68	0.70	0.73		
MTV	0.11	0.26	0.19	0.25	0.28	0.13		1.00	0.90	0.83	0.82	0.84	0.48	0.36	
TLG	0.26		0.31	0.47	0.52	0.26	0.85		1.00	0.74	0.79	0.78	0.79	0.51	0.43
LowGrayZoneEmph	0.29	0.23	0.20	0.33	0.36	0.30	0.27	0.63		1.00	0.73	0.69	0.69	0.40	0.40
InDiffoment	0.11	0.32	0.06	0.27	0.31	0.25	0.15	0.68	0.83	0.79		1.00	0.94	0.94	0.40
ShotRunEmph	0.34		0.25	0.29	0.25	0.12	0.70	0.82	0.78	0.69	0.94		1.00	0.99	0.25
LongRunEmph	0.36		0.22	0.27	0.24	0.12	0.73	0.84	0.79	0.69	0.94	0.99		1.00	0.26
Sphericity	0.24		0.13	0.29	0.29	0.21	0.22	0.41	0.48	0.51	0.40	0.40	0.25	0.26	
NHOmax		0.24	0.34	0.32	0.43	0.45	0.30	0.38	0.43	0.40	0.42	0.32	0.33	0.40	1.00
NHOpeak		0.32	0.21	0.35	0.34	0.35	0.39	0.49	0.57	0.60	0.53	0.59	0.49	0.50	0.60

complémentaire



Team building – Thème 5 - 16-17 novembre 2023 | 12



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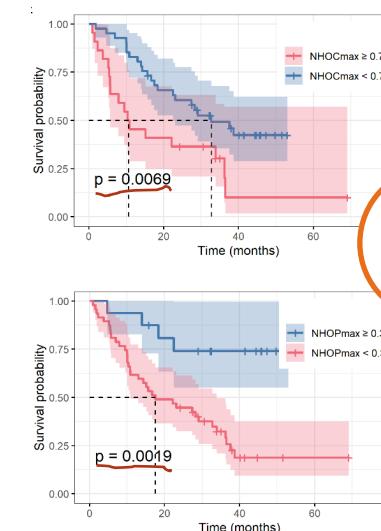
Evolutionary dynamics at the tumor edge reveal metabolic imaging biomarkers

Juan Jiménez-Sánchez ¹, Jesús J Bosque ¹, Germán A Jiménez-Londroño ², David Molina-García ¹, Álvaro Martínez ^{1,3}, Julián Pérez-Beteta ¹, Carmen Ortega-Sabater ¹, Antonio F Honguero Martínez ⁴, Ana M García Vicente ², Gabriel F Calvo ⁵, Victor M Pérez-García ⁵

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SUVmax to tumor perimeter distance: a robust radiomics prognostic biomarker in resectable non-small cell lung cancer patients

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pronostique



Article en révision dans le JNM

Illustration n°2 : développer et valider un modèle – Hornella



Prédiction de la réponse aux inhibiteurs de tyrosine Kinase (TKI) chez des patients atteints de cancer broncho-pulmonaire avec mutation EGFR



Precision
Predict

2020-2024

PI : Nicolas Girard

bpifrance

HEALTH
DATA HUB

Characteristic	HR	95% CI	p-value
age	1.04	1.02, 1.07	0.001
localisation_mutat_EGFR_E19	—	—	
0	0.37	0.21, 0.63	<0.001
1	1.64	0.97, 2.76	0.065
META_FOIE	—	—	
high	—	—	
low	0.45	0.19, 1.05	0.066
SUVmeanFoi	—	—	
high	—	—	
low	2.41	1.20, 4.81	0.013
SUVrate_foi	—	—	
high	—	—	
low	3.20	1.41, 7.27	0.005
SUVmax_PrimPul	—	—	
high	—	—	
low	0.40	0.23, 0.72	0.002
NHOCmax_PrimPul	—	—	
high	—	—	
low	1.86	1.01, 3.45	0.048
SPDmax_PrimPul	—	—	
high	—	—	
low	5.28	2.60, 10.7	<0.001
Sphericity_PrimPul	—	—	
high	—	—	
low	0.64	0.35, 1.17	0.15
sdNHOCmax	—	—	
high	—	—	
low	0.48	0.22, 1.04	0.064

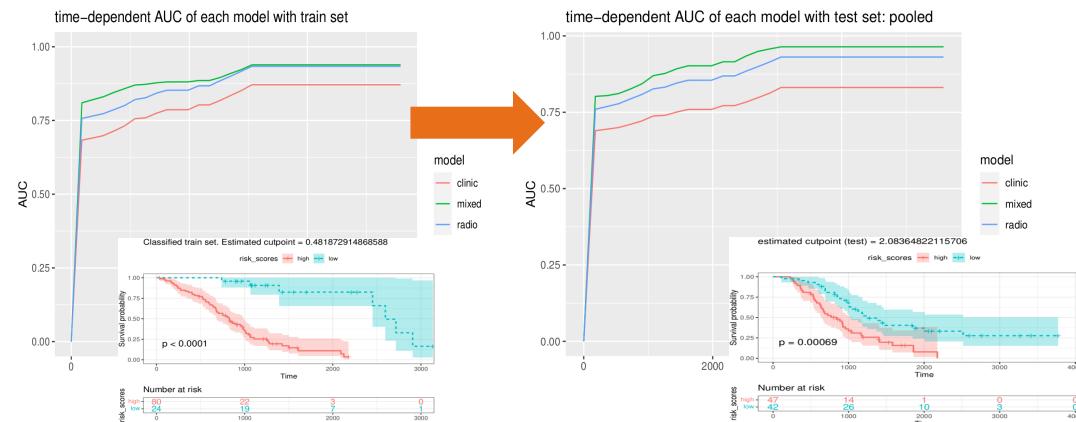


Illustration n°3 : 1+1 > 2 – Nicolas

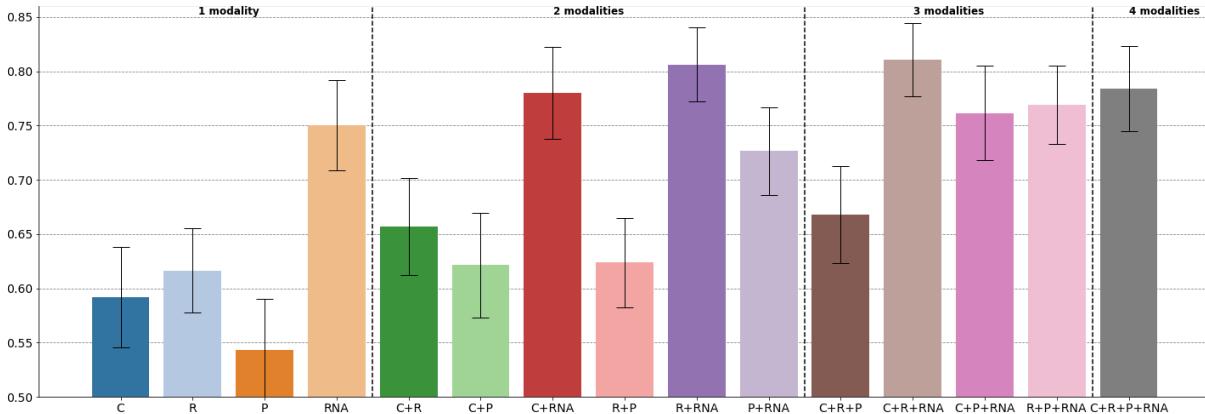


Prédiction de la réponse à l'immunothérapie



Données cliniques, pathomiques, génomiques et radiomiques (TEP-FDG)
317 patients avec CPNPC traité par immunothérapie (Institut Curie)

Survie globale à 1 an (AUC) – Fusion tardive de modèles XGBoost



C : Clinique

R : Radiomique

P : Pathomique

RNA : Génomique

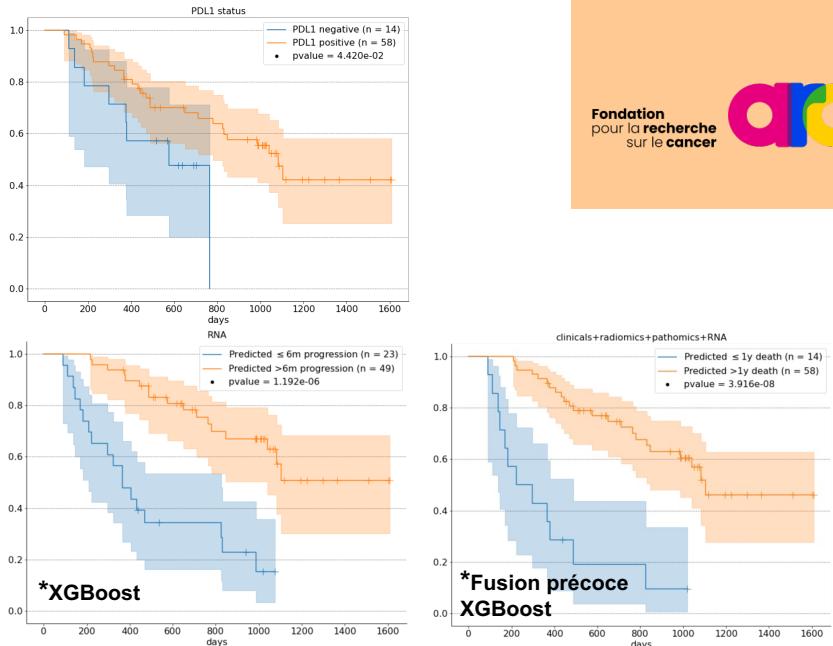
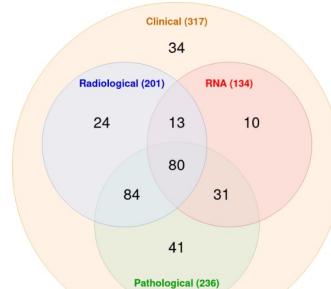


Illustration n°4 : évaluation de LION – Mathilde



Evaluation d'une segmentation automatique des lésions tumorales



93 patients avec un CPNPC avancé (Institut Curie)

Segmentation de référence : expert + seuillage > 4 SUV

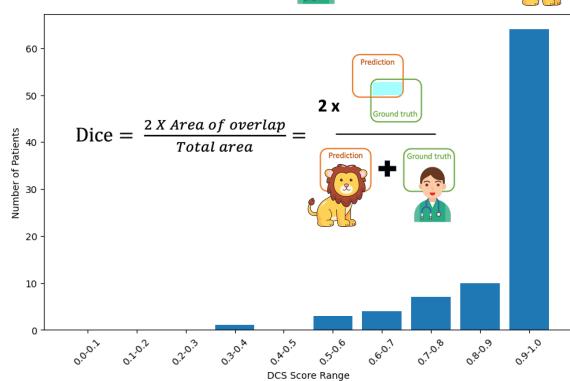
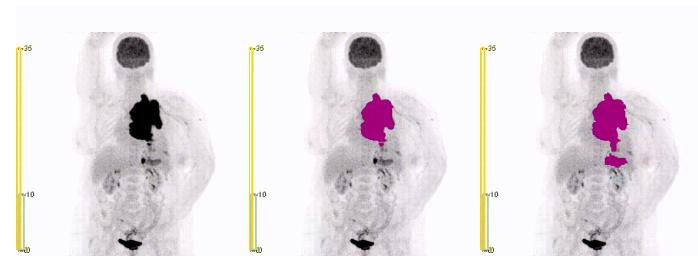


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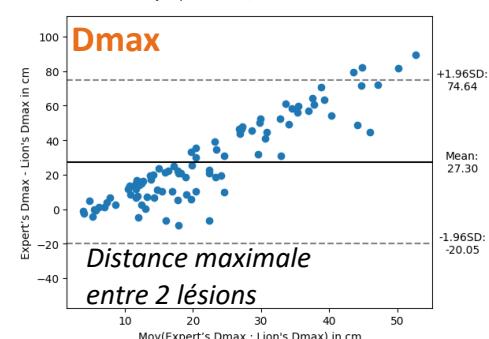
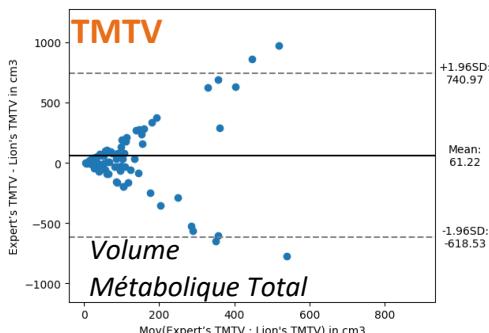
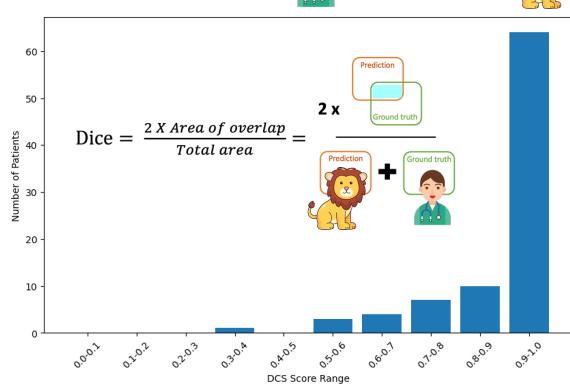
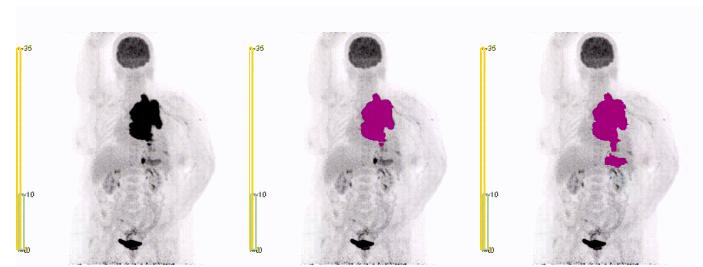


Illustration n°4 : évaluation de LION – Mathilde

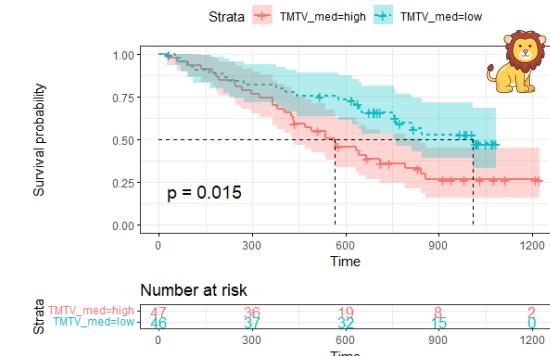
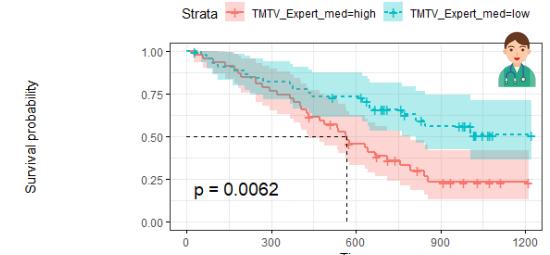
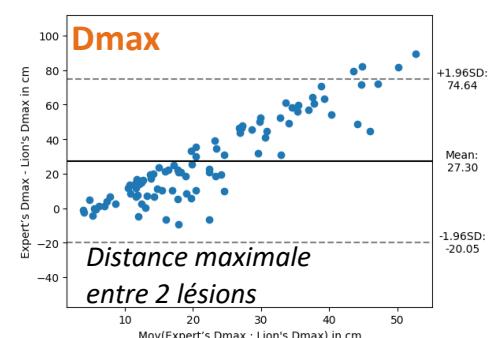
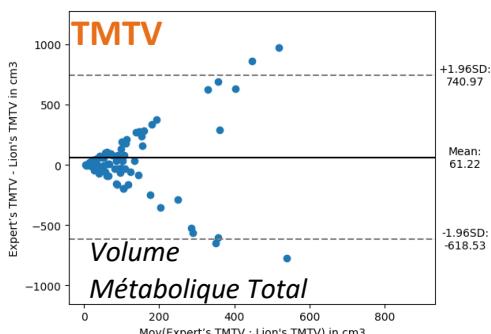
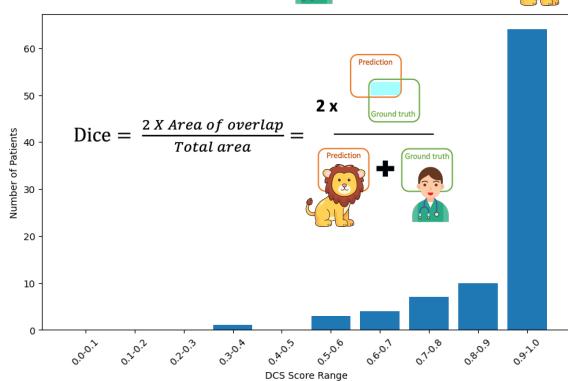
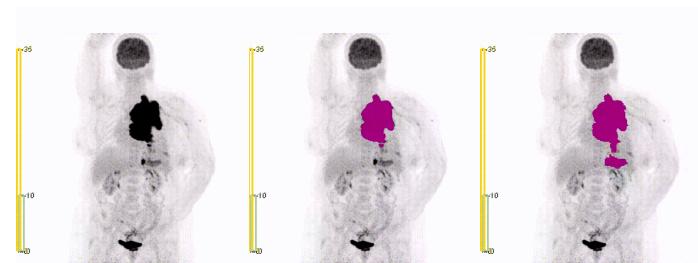


Evaluation d'une segmentation automatique des lésions tumorales



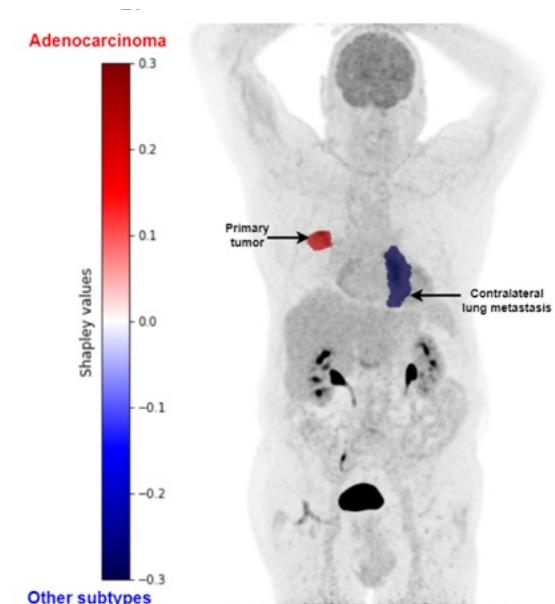
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Autres illustrations

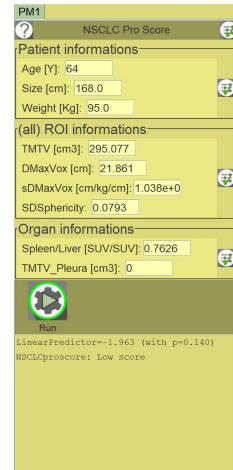
- Prédiction de la réponse à l'immunothérapie chez des patients atteints de cancer du poumon non à petites cellules à partir d'images TEP (Julie)
- Shap-MAP appliquées au cancer du poumon (Nicolas)



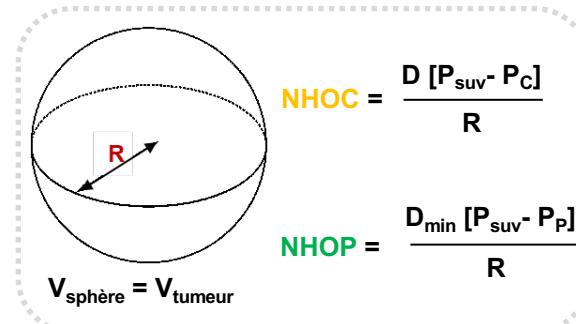
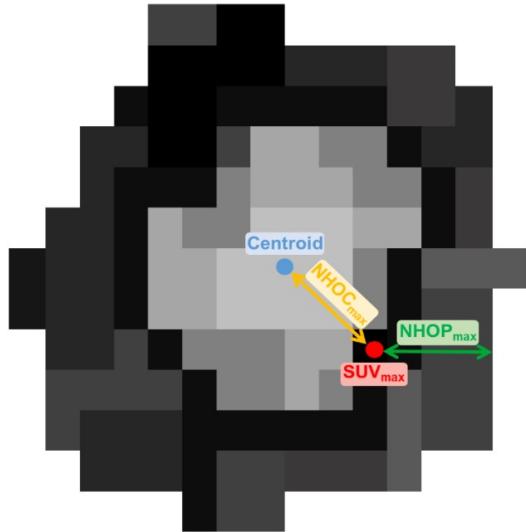
Influence de chaque lesion sur la prédiction du sous-type de CPNC

Perspectives envisagées sur lesquelles cogiter

- Utiliser les données des essais cliniques déjà collectées ?
- LIFEx : plateforme de diffusion de nos nouveaux biomarqueurs/modèles
- Collaboration avec d'autres centres pour la validation externe :
 - Centre Antoine Lacassagne, Nice
 - Institut Jules Bordet, Bruxelles
 - Autres ? Thèses de médecine ?
- Prédire la survenue des toxicités des traitements ?
- Outil de calcul d'un score utilisable en RCP ?







$$\text{NHOC} = \frac{D [P_{\text{suv}} - P_c]}{R}$$

$$\text{NHOP} = \frac{D_{\min} [P_{\text{suv}} - P_p]}{R}$$



calcul 3D