



Robustness and prognostic significance of a recently proposed radiomic feature: normalized distance from hotspot to centroid (NHOC)

Narinée

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Introduction

NHOC...

- normalized distance between the hotspot of the radiotracer uptake and the tumor centroid [Jimenez-sanchez 2021 PNAS]
- proposed as a hallmark of malignant potential: metabolic activity of a tumor is expected to move toward the tumor edge as the tumor grows
- outperformed conventional PET metrics in non-small cell lung cancer (NSCLC) [Jiménez-Londono 2022 European Radiology, Cuplov SNM 2022]

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 - proposed as a hallmark of malignant potential: metabolic activity of a tumor is expected to move toward the tumor edge as the tumor grows
 - outperformed conventional PET metrics in non-small cell lung cancer (NSCLC) [Jiménez-Londono 2022 European Radiology, Cuplov SNM 2022]
-
- ➔ robustness to imaging characteristics (spatial resolution and voxel size)
 - ➔ correlation with conventional PET features
 - ➔ prognostic value to predict survival in NSCLC patients

Mat & Met • database

	Cohort 1	Cohort 2
Number of patients		
Total	99	244
Male	55 (56%)	122 (50%)
Female	44 (44%)	122 (50%)
Age (years)		
Mean $\pm$ SD [range]	66.3 $\pm$ 10.2 [35-86]	65.4 $\pm$ 10.1 [35-87]
NSCLC subtypes		
Adenocarcinoma	58 (58%)	196 (80%)
Squamous cell carcinoma	28 (28%)	24 (10%)
Other	13 (13%)	24 (10%)

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Database	Study	Method	Test
Cohort 1	Robustness	Post-filtering	Bland-Altman
		Resampling	Bland-Altman
		Correlation	Correlogram (Spearman)
		Repeatability	Intraclass Correlation Coefficient
Cohort 2	Survival analysis	Overall survival	Kaplan-Meier

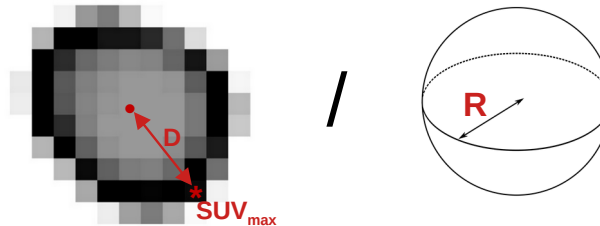
Mat & Met • database

	Cohort 1	Cohort 2	Sub-cohorts	PET scans
Number of patients			TT	93
Total	99	244	I&C	88
Male	55 (56%)	122 (50%)	I	63
Female	44 (44%)	122 (50%)		
Age (years)				
Mean ± SD [range]	66.3 ± 10.2 [35-86]	65.4 ± 10.1 [35-87]		
NSCLC subtypes				
Adenocarcinoma	58 (58%)	196 (80%)		
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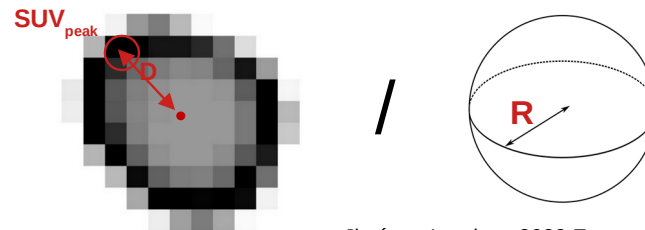
Mat & Met • NHOC definition

NHOC_{max}: distance (D) from the tumor centroid to the voxel with maximum SUV (SUV_{max}) divided by the radius (R) of a hypothetical sphere having the same volume as the tumor.



Jimenez-sanchez 2021 PNAS

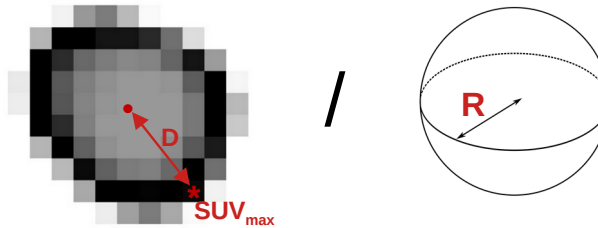
NHOC_{peak}: distance (D) from the tumor centroid to the hotspot with maximum average SUV (within a 1cm³ spherical volume, SUV_{peak}) divided by the radius (R) of a hypothetical sphere having the same volume as the tumor.



Jiménez-Londono 2022 European Radiology

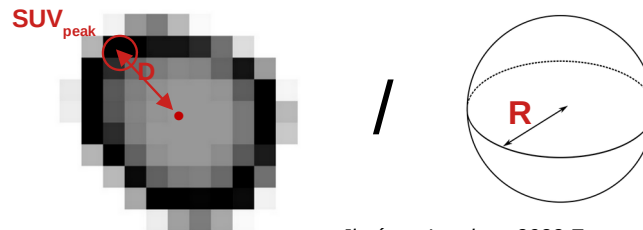
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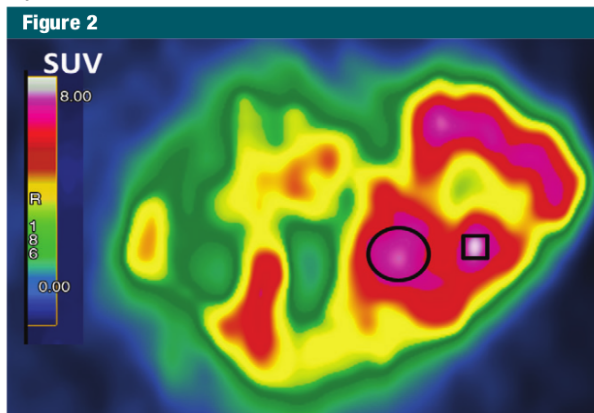


Jiménez-Londono 2022 European Radiology

SUV_{peak} VOI is not always centered (or does not even contain) the voxel with the highest maximum SUV

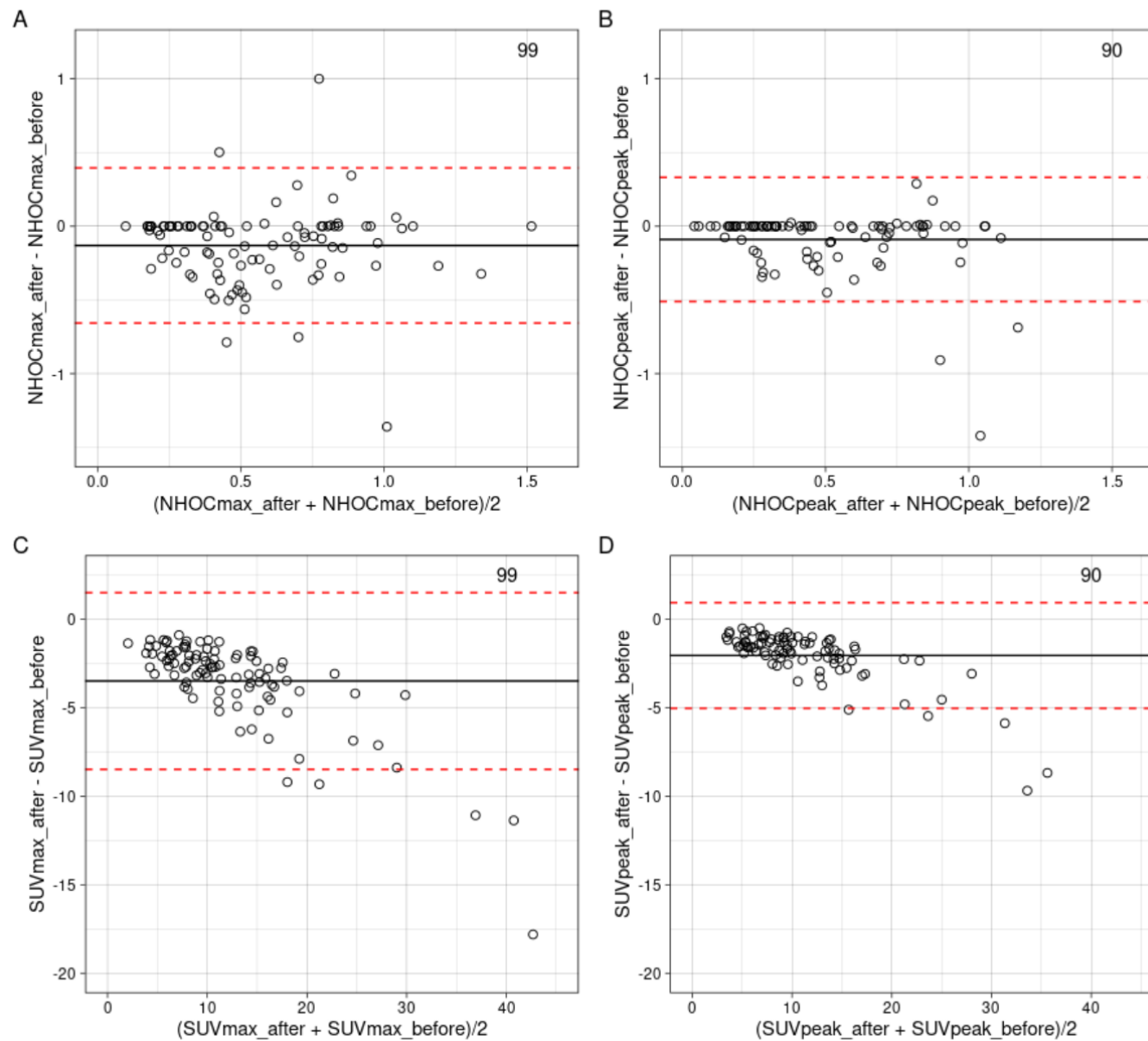
Hyun et al 2016 Practical PERCIST 1.0

Figure 2

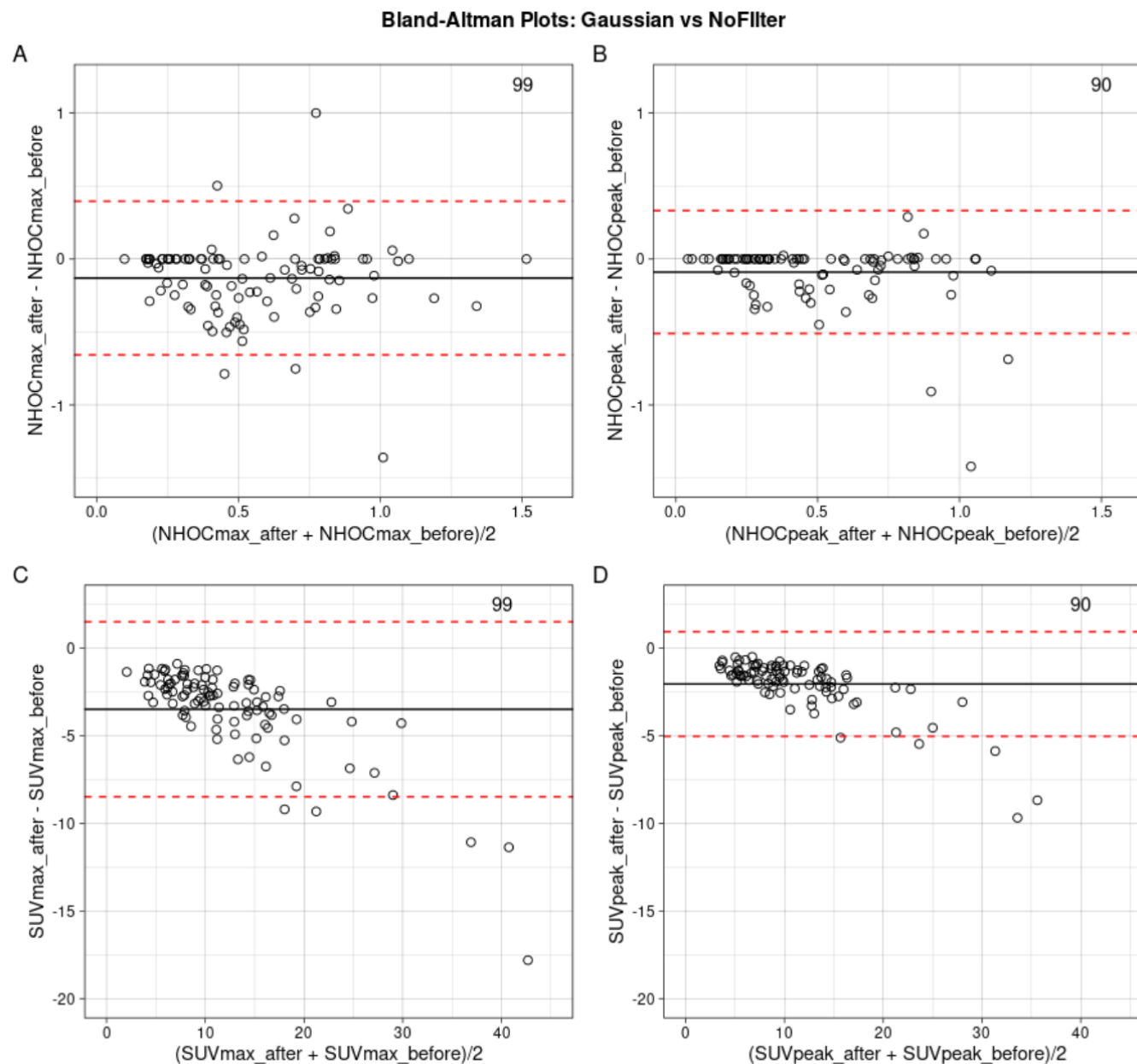


Results • robustness • filtering

Bland-Altman Plots: Gaussian vs NoFilter



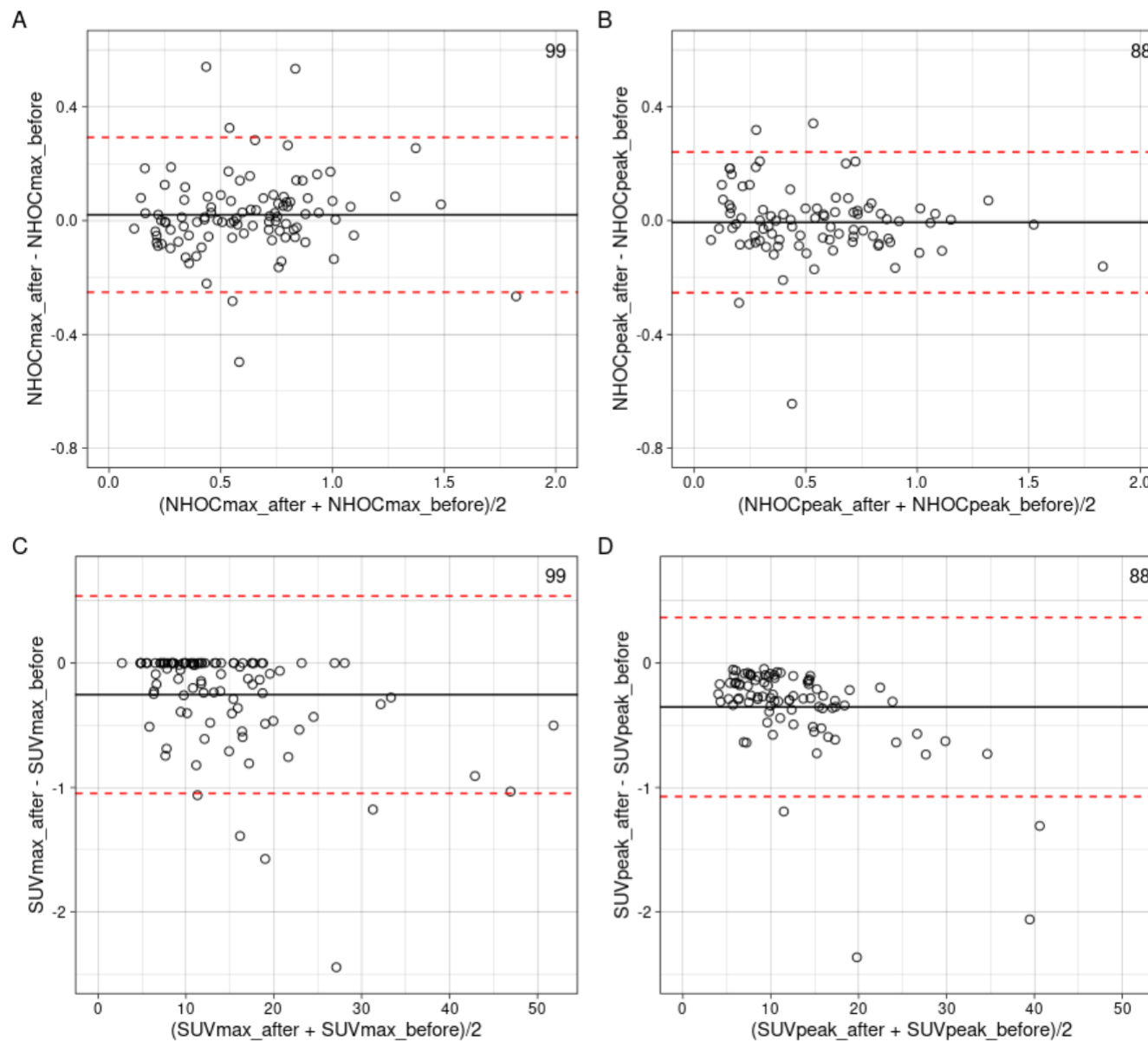
Results • robustness • filtering



NHOCs less affected by spatial resolution...

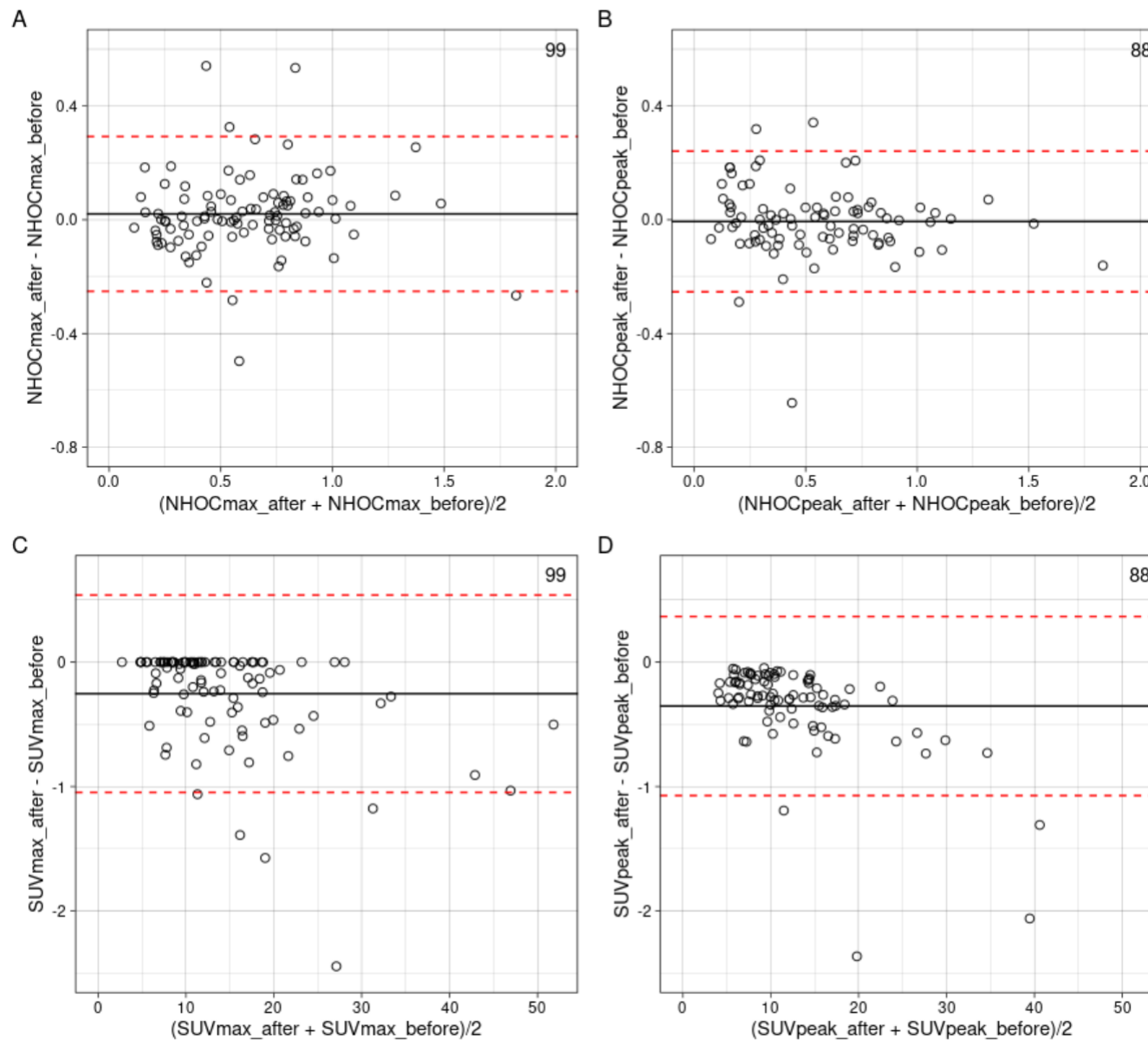
Results • robustness • resampling

Bland-Altman Plots: Resampling 4x4x4 vs 2x2x2



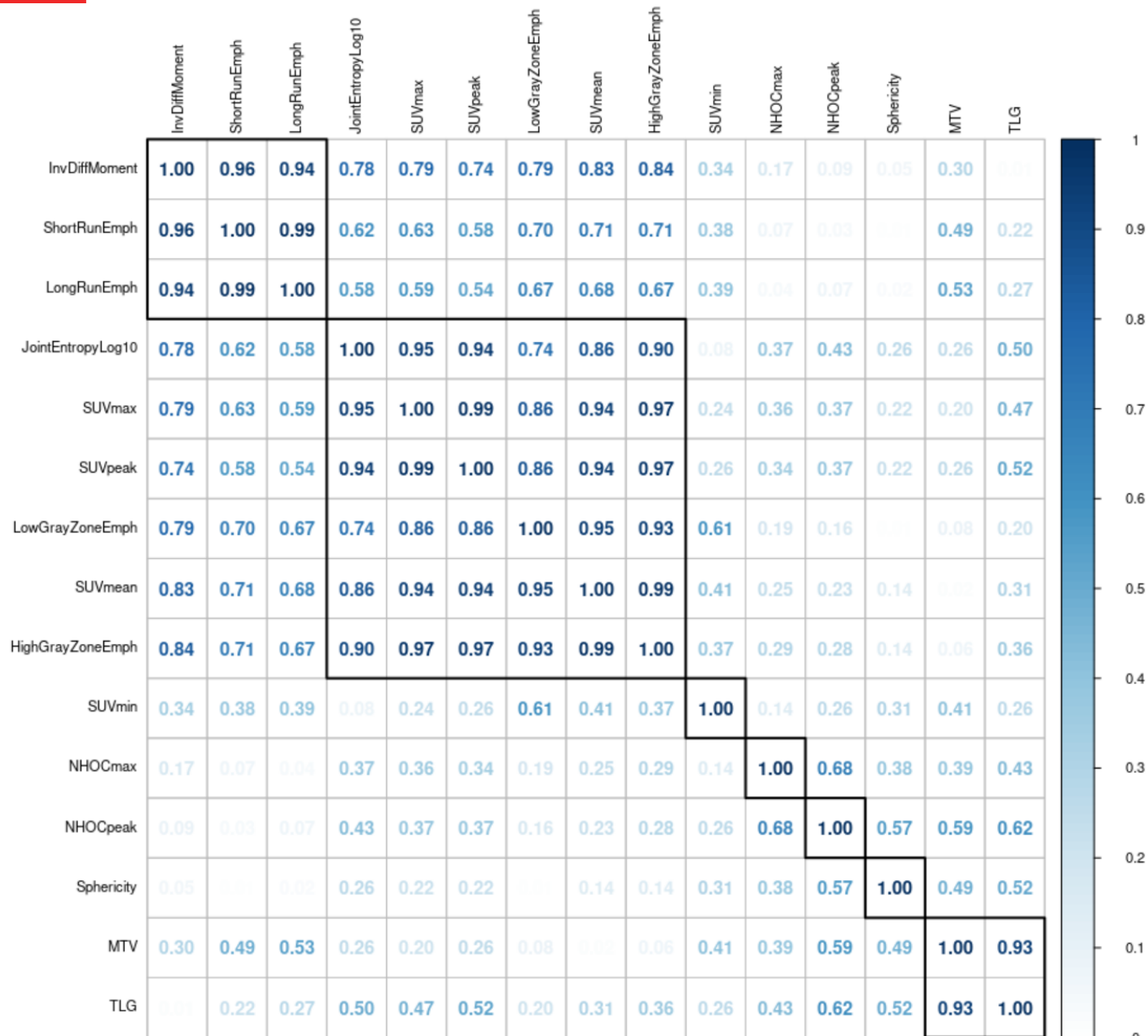
Results • robustness • resampling

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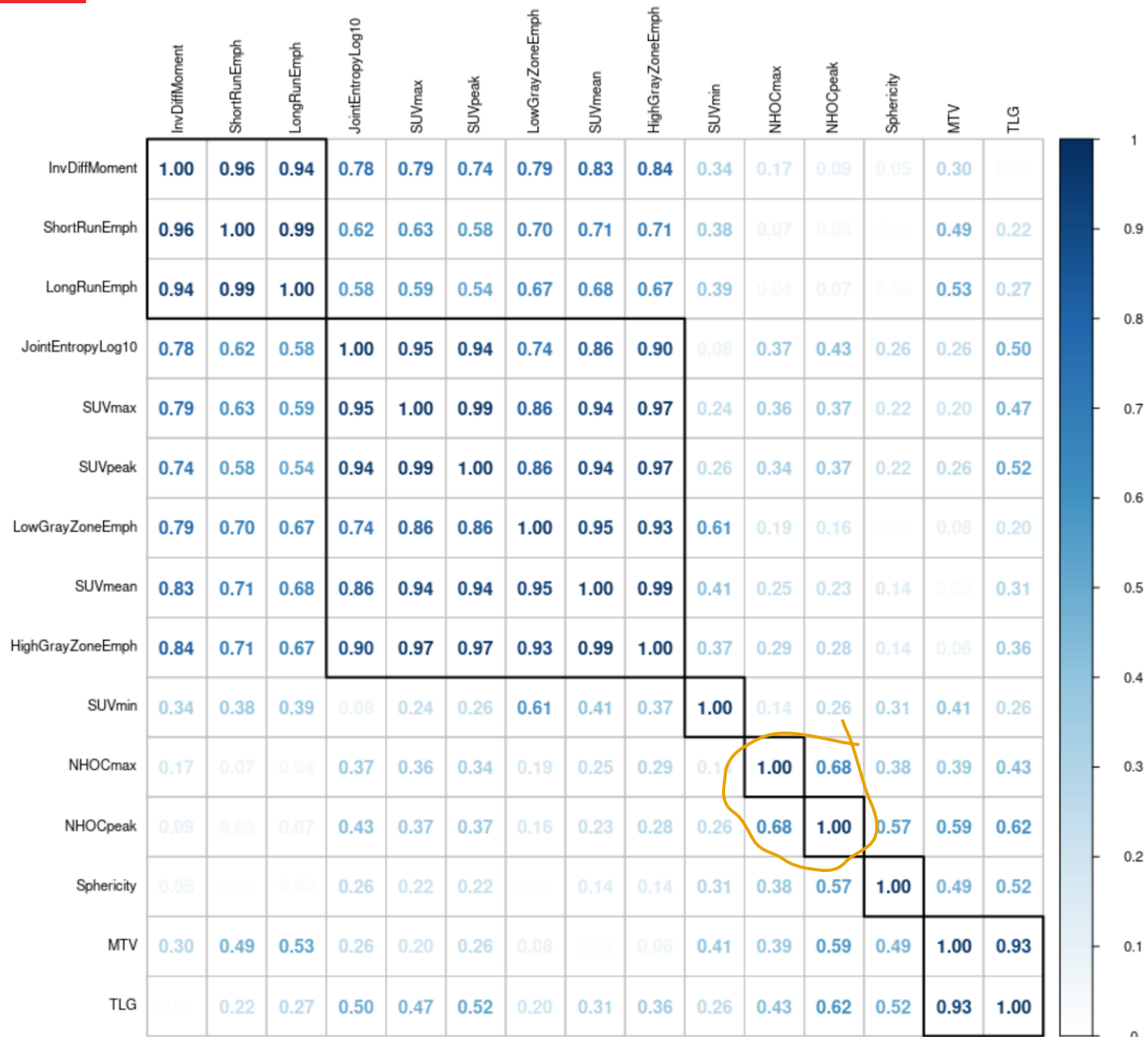
NHOCs less affected by voxel size...

Results • complementarity



Feature	Definition
InvDiffMoment	Homogeneity of gray levels
ShortRunEmph	Quantification of short homogenous series
LongRunEmph	Quantification of long homogeneous series
JointEntropyLog10	Entropy
SUVmax	Maximum SUV
SUVpeak	Average SUV (maximal) over a 1mL-volume
LowGrayZoneEmph	Quantification of low gray level series
SUVmean	Average SUV
HighGrayZoneEmph	Quantification of high gray level series
SUVmin	Minimum SUV
NHOCmax	Normalized distance from hottest spot to centroid
NHOCpeak	Normalized distance from hotspot (1ml) to centroid
Sphericity	Coefficient of sphericity
MTV	Metabolic tumor volume
TLG	Total lesion glycolysis

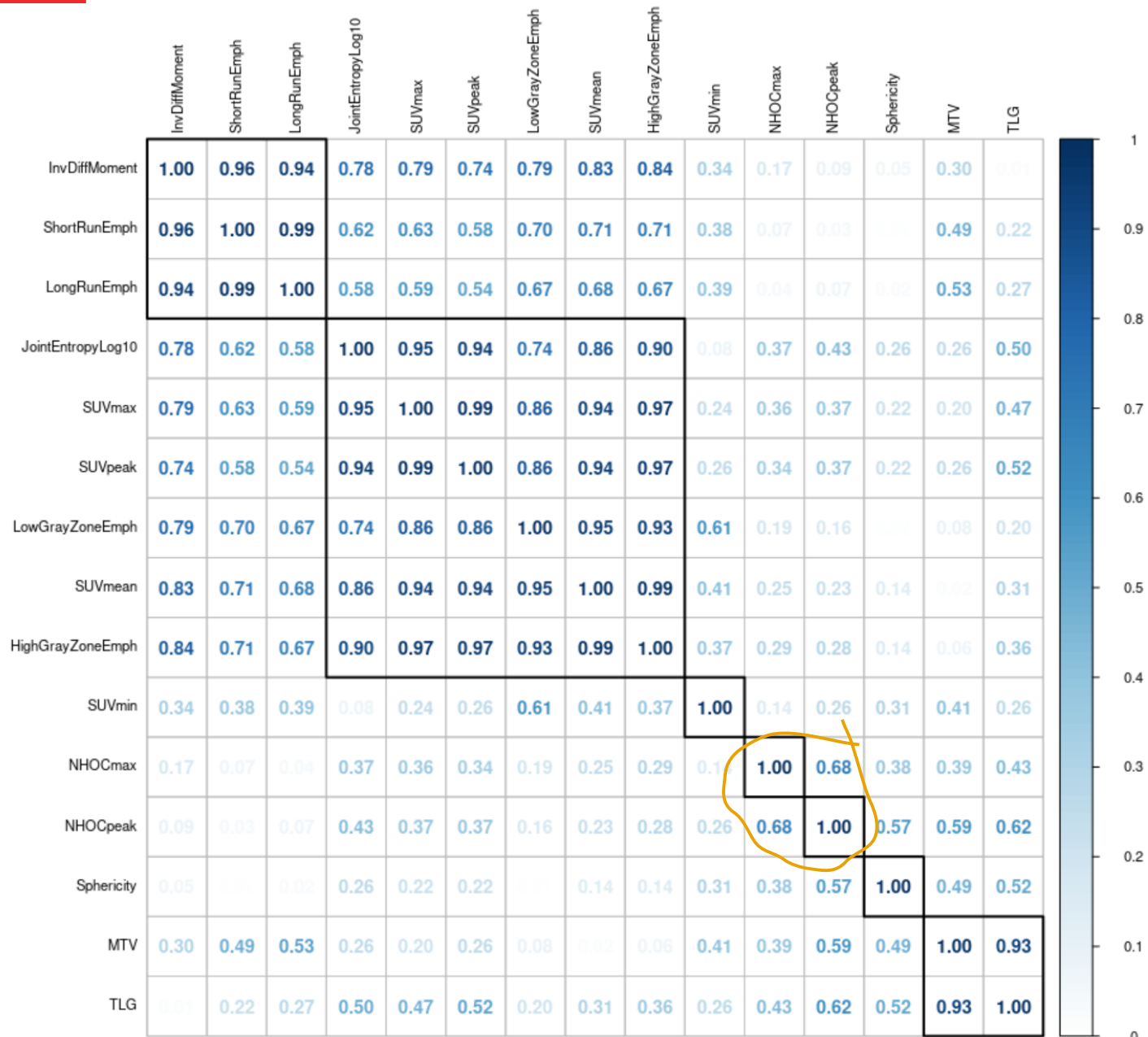
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NHOCs yielded an independent subgroup of PET metrics

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<!=> If NHOCpeak not assessable...
replaced by NHOCmax in survival
analysis

NHOCs yielded an independent subgroup of PET metrics

Results • repeatability

	ICC (rater1, rater2)
SUVmin	0.766
SUVmax	1.000
SUVmean	0.974
SUVpeak	0.999
NHOCmax	0.918
NHOCpeak	0.945
MTV	0.992
TLG	0.987
InvDiffMoment	0.972
JointEntropyLog10	0.947
Sphericity	0.763
ShortRunEmph	0.995
LongRunEmph	0.996
LowGrayZoneEmph	0.988
HighGrayZoneEmph	0.983

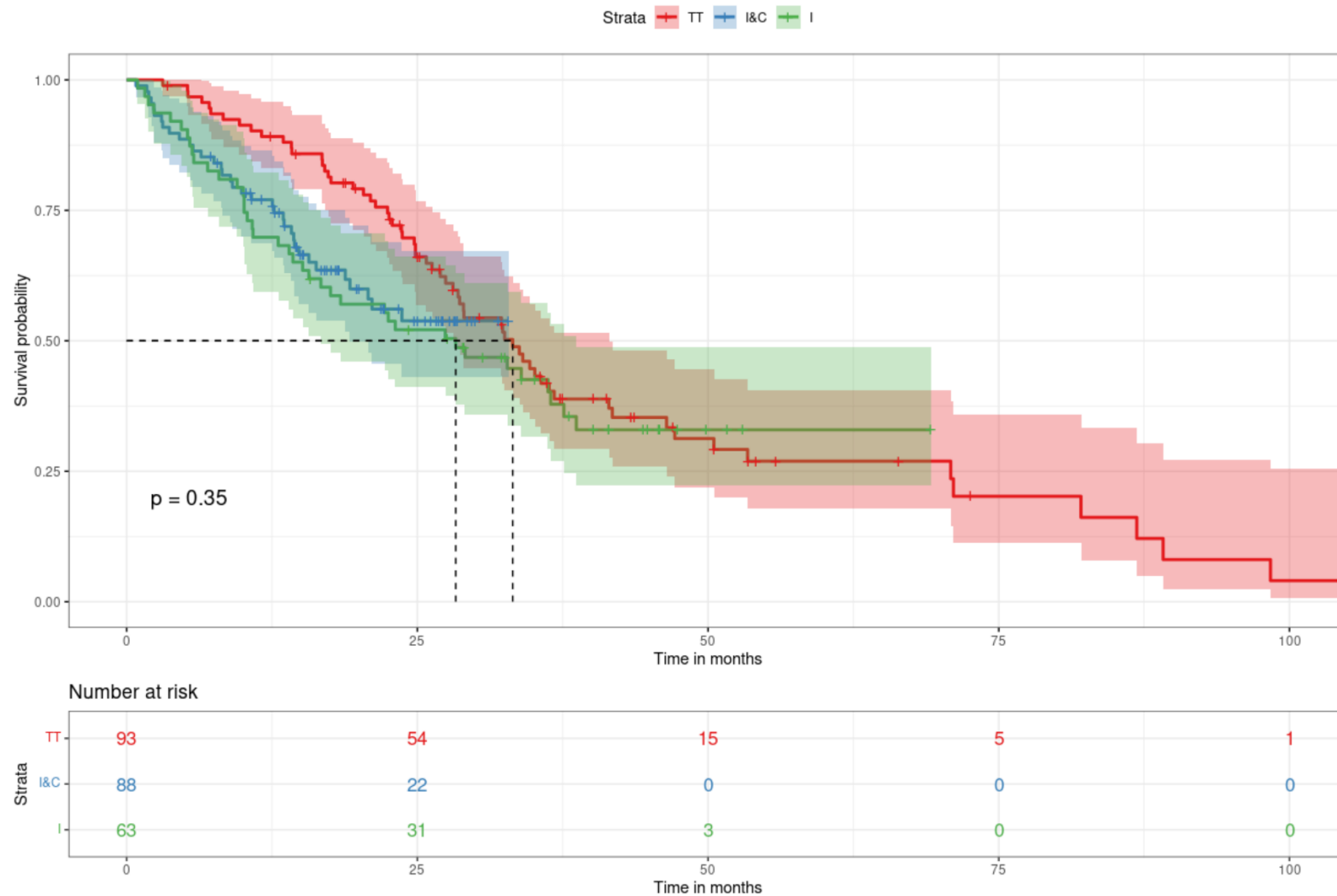
Intraclass Correlation Coefficient, n=30 lesions

Low dependency of NHOC on tumor delineation

Results • survival analysis

Feature	TT		I&C		I	
	cutoff	p-value	cutoff	p-value	cutoff	p-value
NHOCmax	0.674	0.310	0.608	0.160	0.793	0.007
NHOCpeak	0.580	0.230	0.439	0.210	0.502	0.005
SUVmin	2.7	0.110	3.7	0.058	0.9	0.016
SUVmax	10.5	0.007	9.1	0.230	18.2	0.110
SUVmean	5.9	0.019	10.3	0.089	12.2	0.007
SUVpeak	9.1	0.027	12.9	0.230	11.9	0.190
MTV	55744	0.029	21376	0.006	20992	0.003
TLG	82.4	0.170	54.2	0.014	194.3	0.002
Sphericity	0.670	0.100	0.721	0.009	0.830	<0.001
JointEntropyLog10	2.569	0.013	2.642	0.180	2.422	0.013
InvDiffMoment	0.244	0.025	0.184	0.059	0.266	<0.001
ShortRunEmph	0.963	0.043	0.967	0.038	0.952	0.003
LongRunEmph	1.266	0.041	1.131	0.038	1.199	0.003
LowGrayZoneEmph	0.006	0.310	0.001	0.270	0.003	0.049
HighGrayZoneEmph	481.4	0.043	1179.6	0.069	531.9	0.091

Results • survival analysis

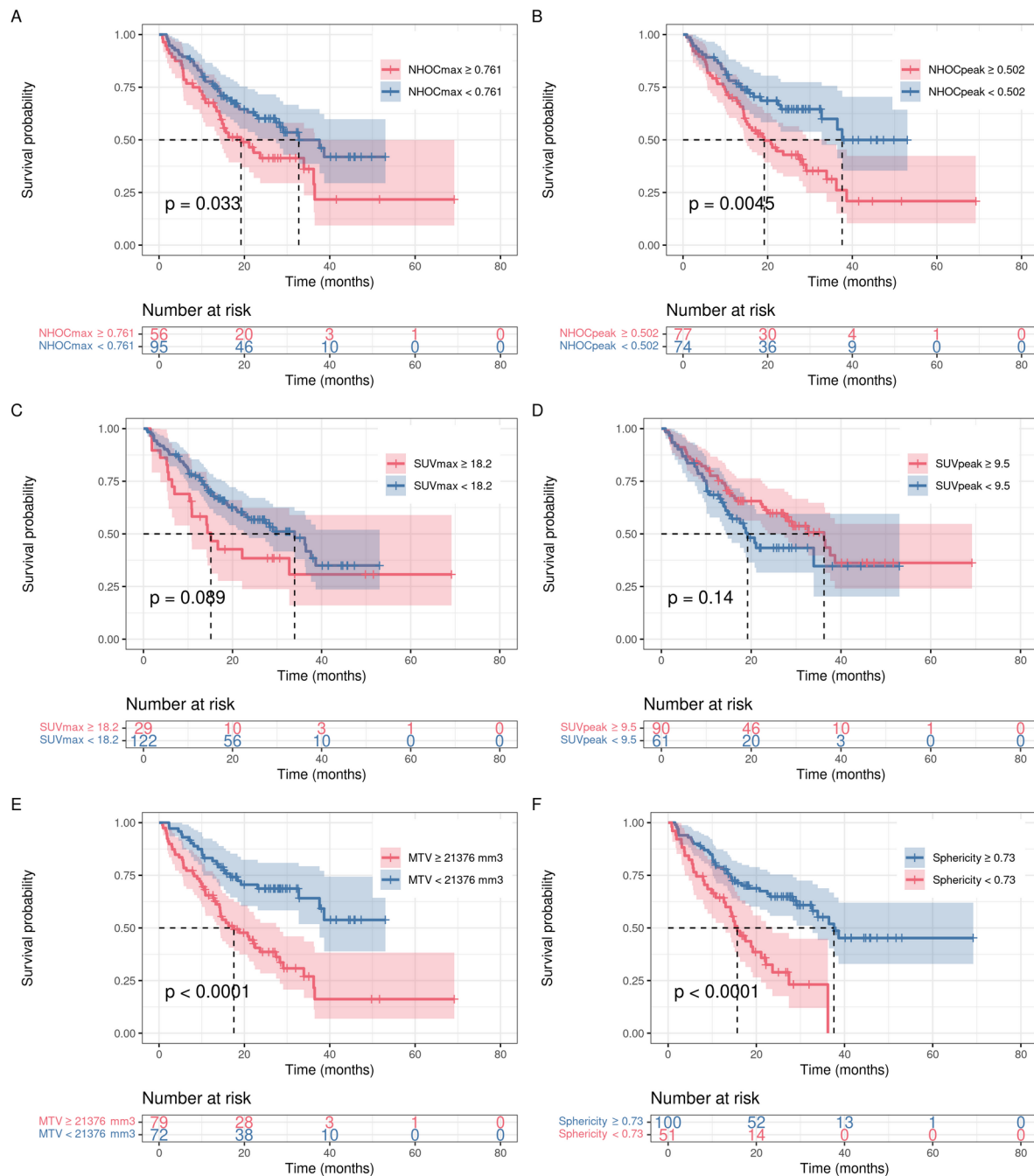


Results • survival analysis

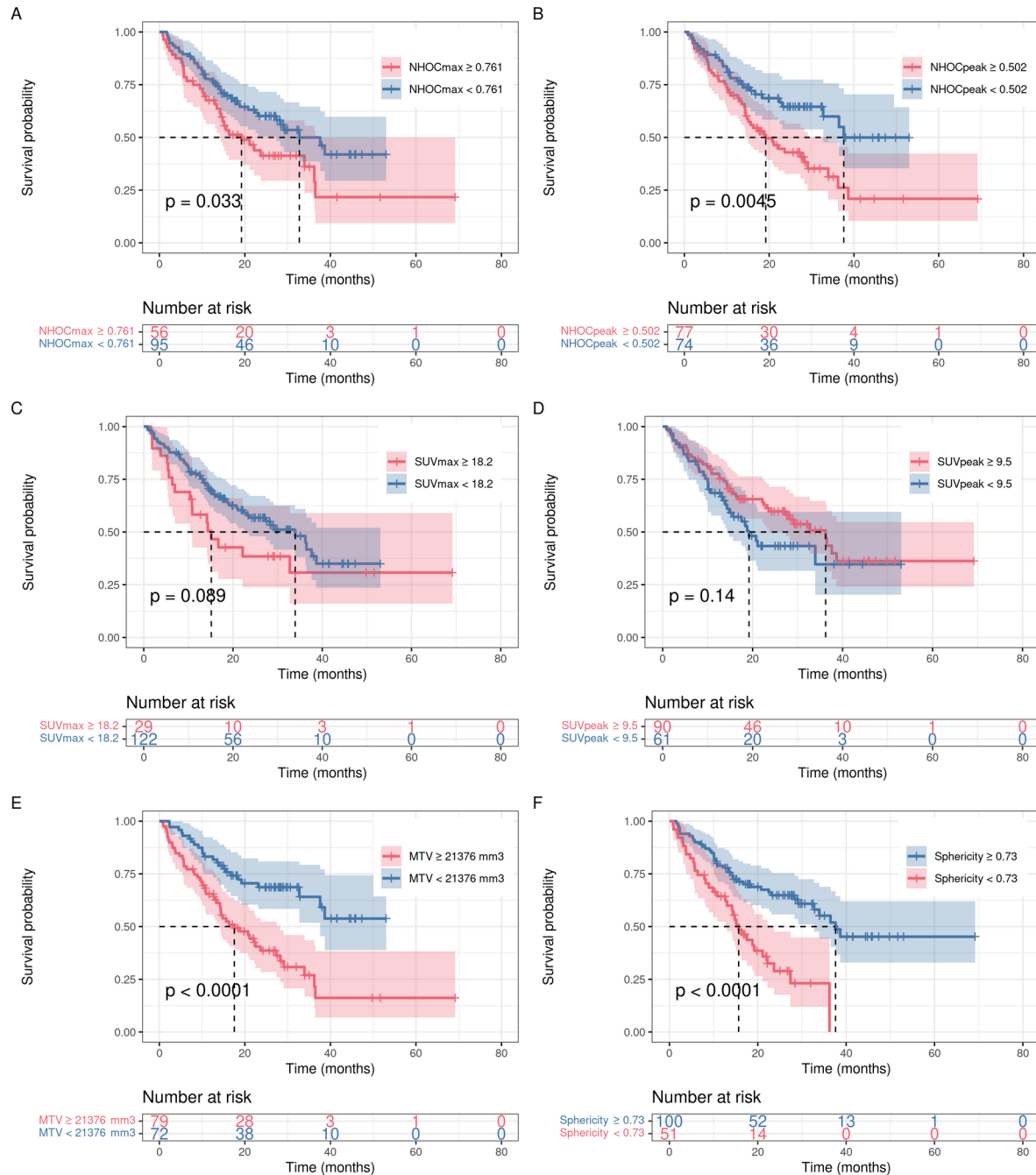
Feature	TT		I&C		I		I±C	
	cutoff	p-value	cutoff	p-value	cutoff	p-value	cutoff	p-value
NHOCmax	0.674	0.310	0.608	0.160	0.793	0.007	0.761	0.033
NHOCpeak	0.580	0.230	0.439	0.210	0.502	0.005	0.502	0.005
SUVmin	2.7	0.110	3.7	0.058	0.9	0.016	0.663	0.020
SUVmax	10.5	0.007	9.1	0.230	18.2	0.110	18.2	0.089
SUVmean	5.9	0.019	10.3	0.089	12.2	0.007	3.3	0.004
SUVpeak	9.1	0.027	12.9	0.230	11.9	0.190	9.5	0.140
MTV	55744	0.029	21376	0.006	20992	0.003	21376	<0.001
TLG	82.4	0.170	54.2	0.014	194.3	0.002	91.202	0.002
Sphericity	0.670	0.100	0.721	0.009	0.830	<0.001	0.730	<0.001
JointEntropyLog10	2.569	0.013	2.642	0.180	2.422	0.013	2.648	0.016
InvDiffMoment	0.244	0.025	0.184	0.059	0.266	<0.001	0.292	0.001
ShortRunEmph	0.963	0.043	0.967	0.038	0.952	0.003	0.927	0.002
LongRunEmph	1.266	0.041	1.131	0.038	1.199	0.003	1.178	0.019
LowGrayZoneEmph	0.006	0.310	0.001	0.270	0.003	0.049	0.003	0.088
HighGrayZoneEmph	481.4	0.043	1179.6	0.069	531.9	0.091	500.933	0.036

TT: targeted therapy, I&C: immunotherapy+chemotherapy, I: immunotherapy

Results • survival analysis

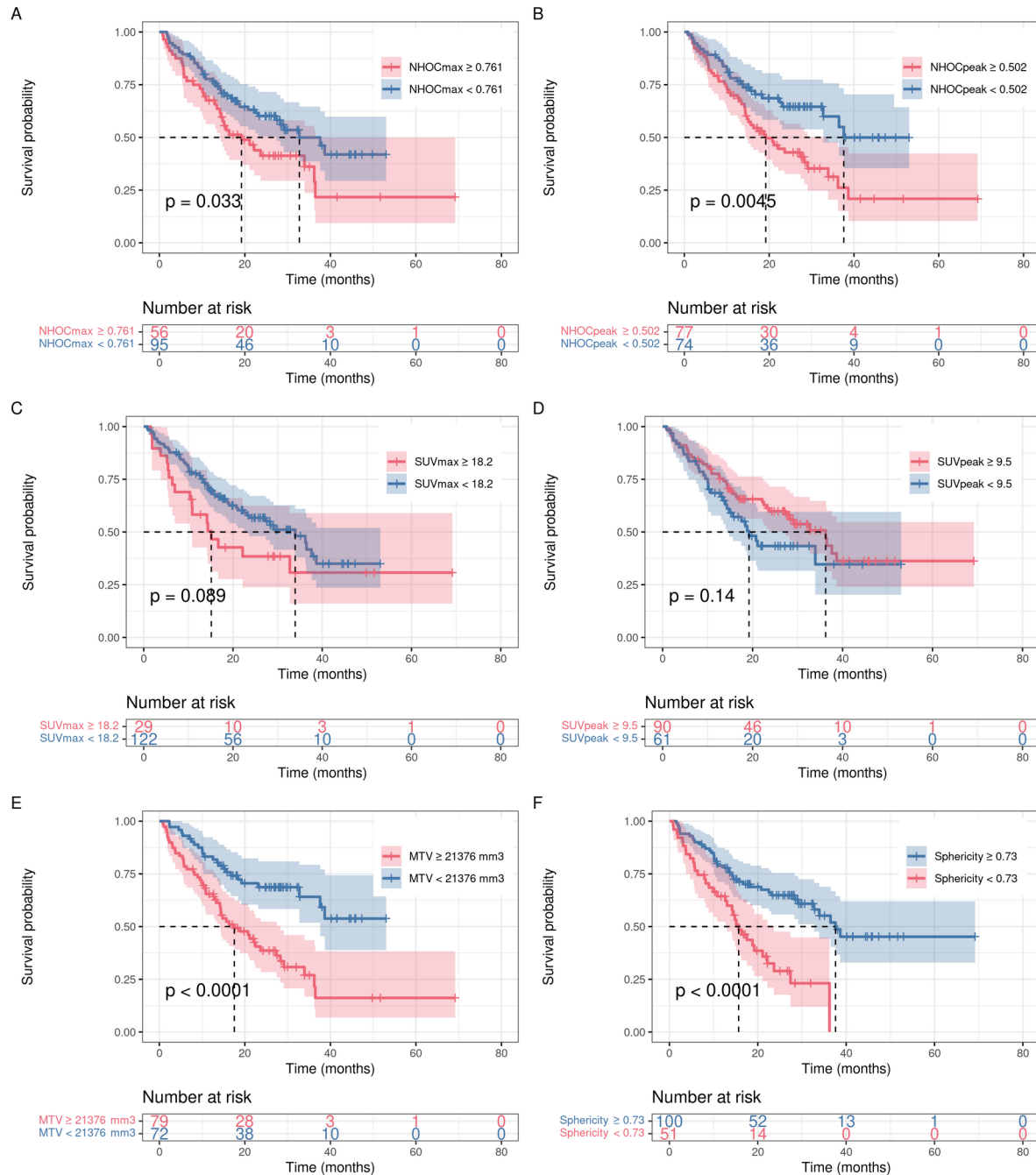


Results • survival analysis



NHOCs predict overall survival...

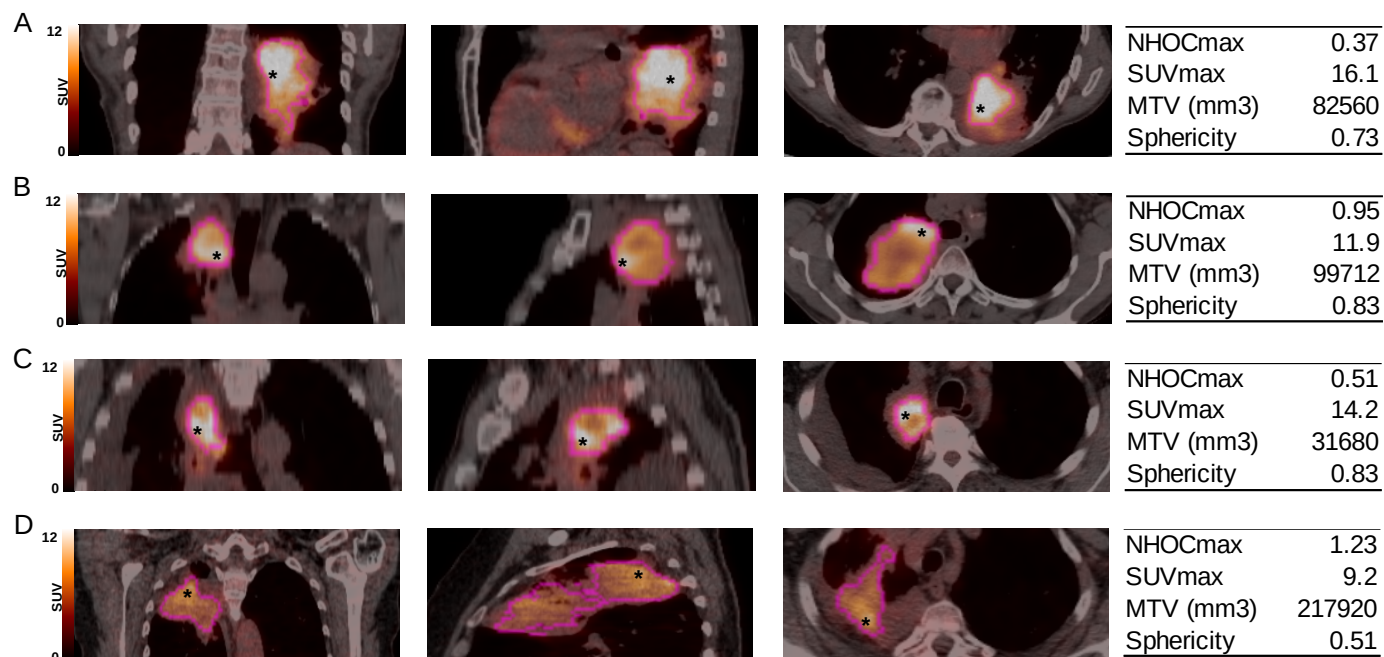
Results • survival analysis



<!-- NHOcpeak (SUVpeak)
replaced by NHOcmax (SUVmax)
in 31/151 lesions

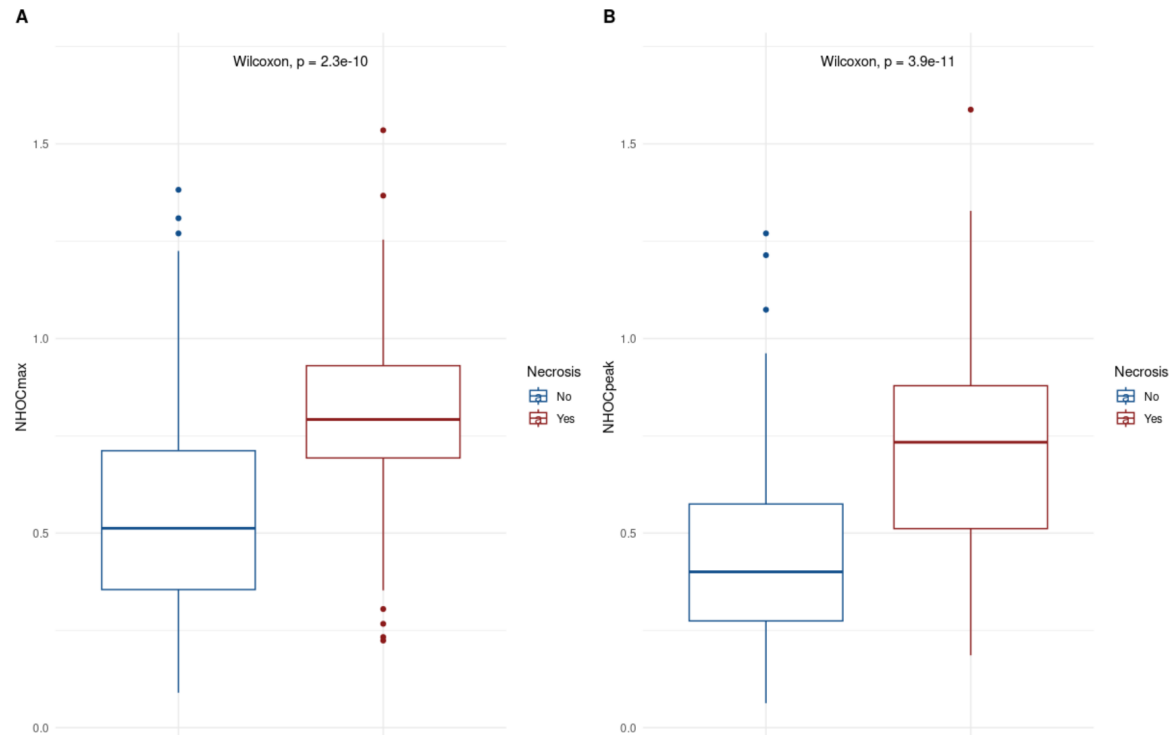
NHOCs predict overall survival...

Supplementary data • representative illustrations



Higher NHOC values for lesions with a necrotic core
or of multifocal/diffuse uptake

Supplementary data • Impact of necrosis



NHOC requires the inclusion of the necrotic area!



Conclusion

NHOC...

- little affected by imaging characteristics (spatial resolution and voxel size)
- complementary to SUVs, MTV, TLG, Sphericity and other commonly reported texture features
- prognostic factor for OS in lung cancer patients
- available in free LIFEx software

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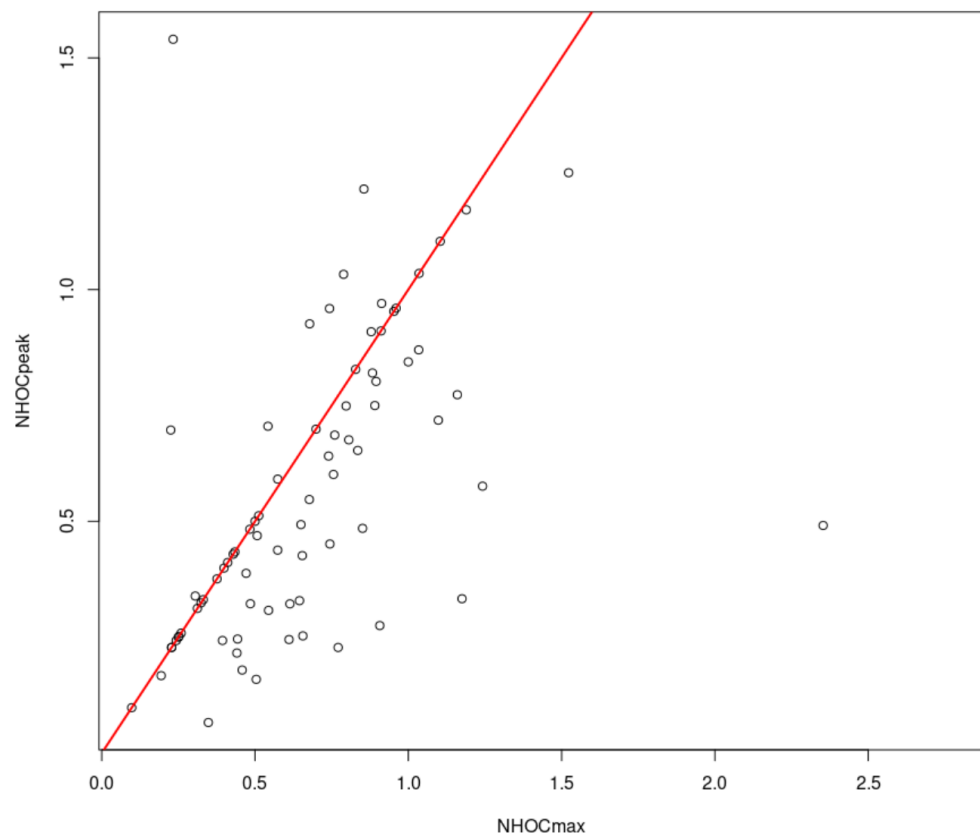
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 - ➔ added value for different types of cancer

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Merci...



| Feature | Cohort 2 | | TT | | I&C | | I | | I±C | |
|-------------------|----------|------------------|--------|--------------|--------|--------------|--------|------------------|--------|------------------|
| | cutoff | p-value | cutoff | p-value | cutoff | p-value | cutoff | p-value | cutoff | p-value |
| NHOCmax | 0.803 | 0.073 | 0.674 | 0.310 | 0.608 | 0.160 | 0.793 | 0.007 | 0.761 | 0.033 |
| NHOCpeak | 0.502 | 0.040 | 0.580 | 0.230 | 0.439 | 0.210 | 0.502 | 0.005 | 0.502 | 0.005 |
| SUVmin | 0.6 | 0.002 | 2.7 | 0.110 | 3.7 | 0.058 | 0.9 | 0.016 | 0.663 | 0.020 |
| SUVmax | 18.2 | 0.034 | 10.5 | 0.007 | 9.1 | 0.230 | 18.2 | 0.110 | 18.2 | 0.089 |
| SUVmean | 3.3 | 0.007 | 5.9 | 0.019 | 10.3 | 0.089 | 12.2 | 0.007 | 3.3 | 0.004 |
| SUVpeak | 5.2 | 0.100 | 9.1 | 0.027 | 12.9 | 0.230 | 11.9 | 0.190 | 9.5 | 0.140 |
| MTV | 30400 | 0.000 | 55744 | 0.029 | 21376 | 0.006 | 20992 | 0.003 | 21376 | <0.001 |
| TLG | 82.4 | 0.001 | 82.4 | 0.170 | 54.2 | 0.014 | 194.3 | 0.002 | 91.202 | 0.002 |
| Sphericity | 0.730 | <0.001 | 0.670 | 0.100 | 0.721 | 0.009 | 0.830 | <0.001 | 0.730 | <0.001 |
| JointEntropyLog10 | 2.888 | 0.160 | 2.569 | 0.013 | 2.642 | 0.180 | 2.422 | 0.013 | 2.648 | 0.016 |
| InvDiffMoment | 0.322 | 0.024 | 0.244 | 0.025 | 0.184 | 0.059 | 0.266 | <0.001 | 0.292 | 0.001 |
| ShortRunEmph | 0.921 | 0.001 | 0.963 | 0.043 | 0.967 | 0.038 | 0.952 | 0.003 | 0.927 | 0.002 |
| LongRunEmph | 1.402 | 0.032 | 1.266 | 0.041 | 1.131 | 0.038 | 1.199 | 0.003 | 1.178 | 0.019 |
| LowGrayZoneEmph | 0.003 | 0.280 | 0.006 | 0.310 | 0.001 | 0.270 | 0.003 | 0.049 | 0.003 | 0.088 |
| HighGrayZoneEmph | 531.9 | 0.420 | 481.4 | 0.043 | 1179.6 | 0.069 | 531.9 | 0.091 | 500.93 | 0.036 |

