International clinical dosimetry intercomparison - Conclusion and perspectives

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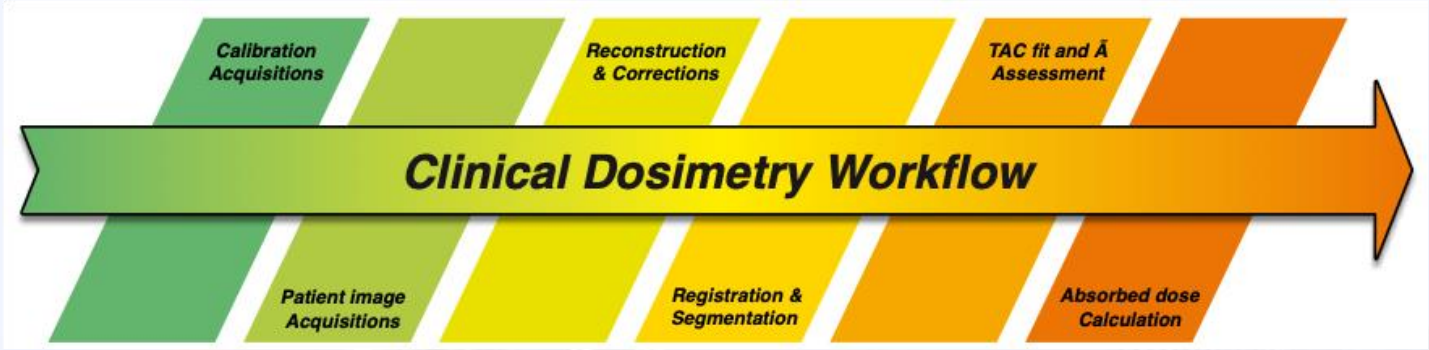
Clinical dosimetry



Bardiès and Gear (2020) Scientific Developments in Imaging and Dosimetry for Molecular Radiotherapy. Clinical Oncology, https://doi.org/10.1016/j.clon.2020.11.005

Current situation:

Dosimetry

- **NO** *difficult to implement/time consuming/complex*
- **YES** *procedures differ in objectives and sophistication ⇒ large heterogeneity?*

IAEA CRP E23005

- “Dosimetry in radiopharmaceutical therapy for personalized patient treatment” in 2017
3 year duration (further extended to 4 years due to the COVID situation)

Objectives:

- Standardization of dosimetric methods in nuclear medicine
- Assisting Member States to develop and implement harmonized dosimetric procedures & assess the global accuracy of dosimetry in NM practice.

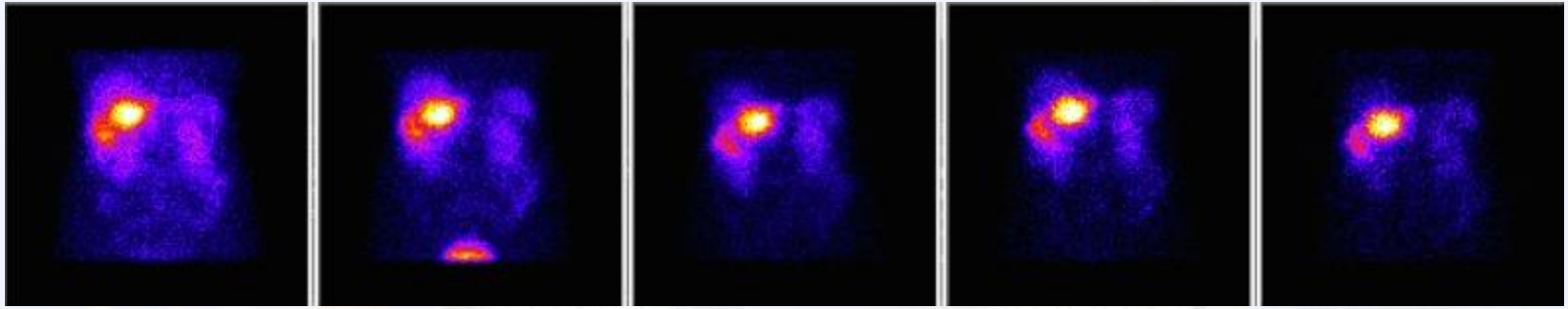
Participants:

- Research institutions in Colombia, Croatia, Cuba, France, India, Indonesia, South Africa, and the United States of America.

Methods:

Patient underwent Lutathera® treatment in 4 cycles

5 SPECT/CT acquisitions post injection



1 hour p.i. | 4 hours p.i. | 24 hours p.i. | 48 hours p.i. | 96 hours p.i.

Gamma camera and acquisitions:

GE Infinia Hawkeye 4 (dual head)

MEGP* collimator + ⅜" NaI crystal size

Auto-contour detector motion

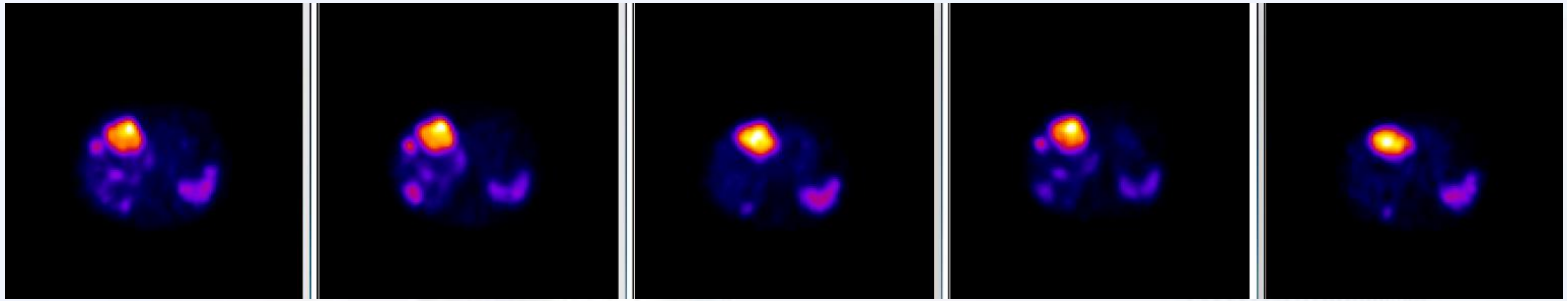
128 x 128 matrix size; 60 projections/head

15 seconds per projection

Energy window: 208 keV ± 20%

Reconstructed images

Cycle 3



1 hour p.i. | 4 hours p.i. | 24 hours p.i. | 48 hours p.i. | 96 hours p.i.

Hermes v2.80

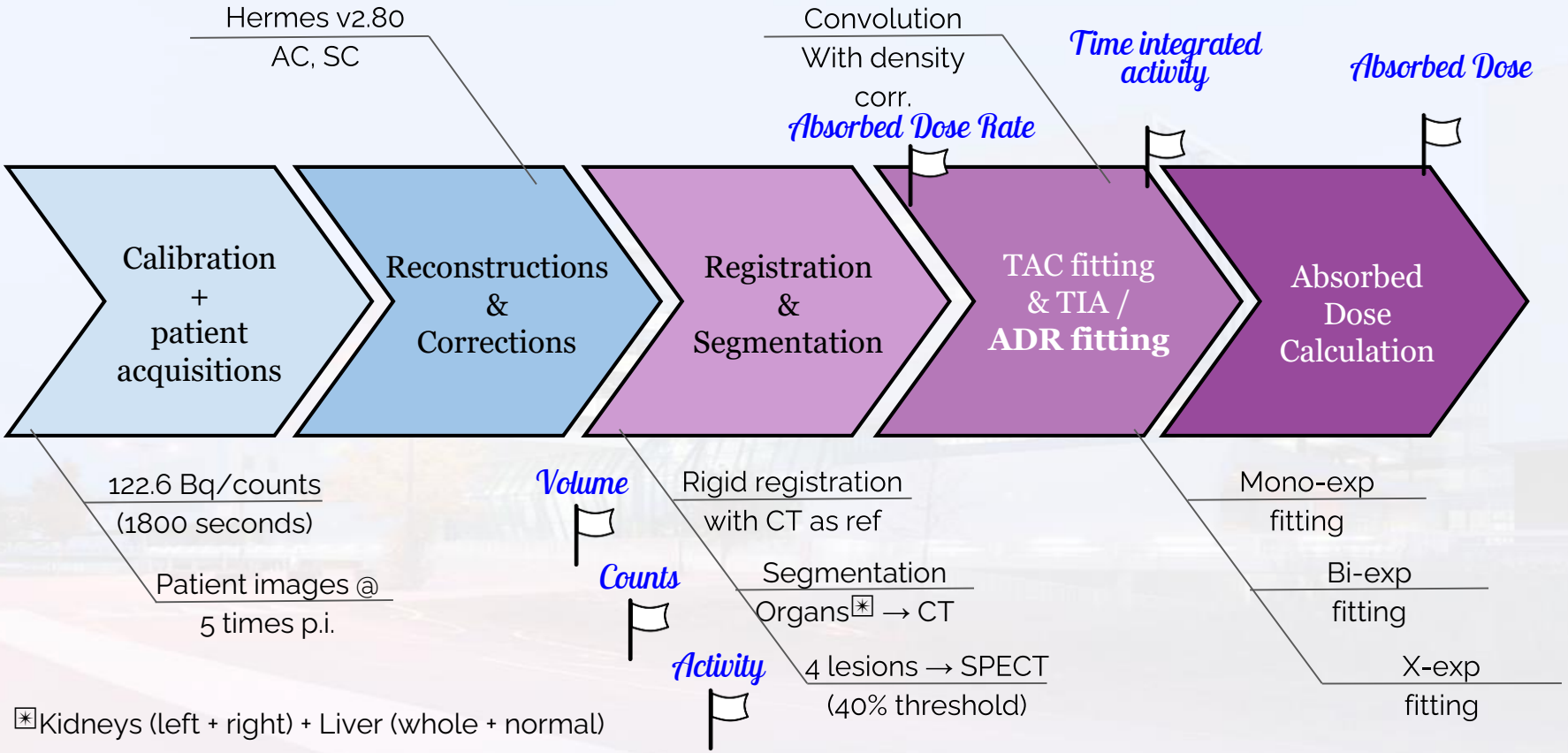
OSEM algorithm (3i ,15ss); 0.8 cm Gaussian post-filter

Low dose CT based attenuation; In-built MC based scatter correction

Calibration factor: 122.6 Bq/counts (with NEMA IEC phantom)

9 participants → performed dosimetry on these reconstructed images using Planet® Dose (DOSIsoft SA) - v3.1.1 (CE marked)

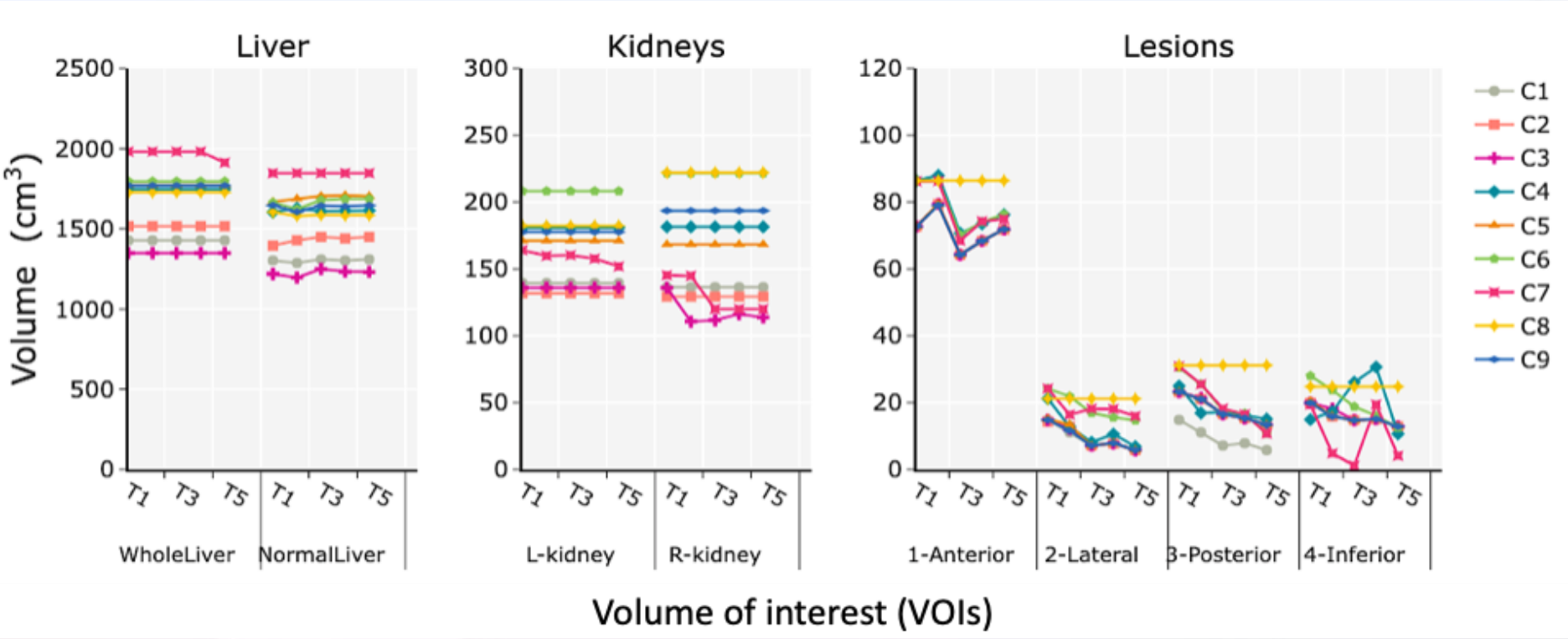
Standard protocol chosen



✳Kidneys (left + right) + Liver (whole + normal)

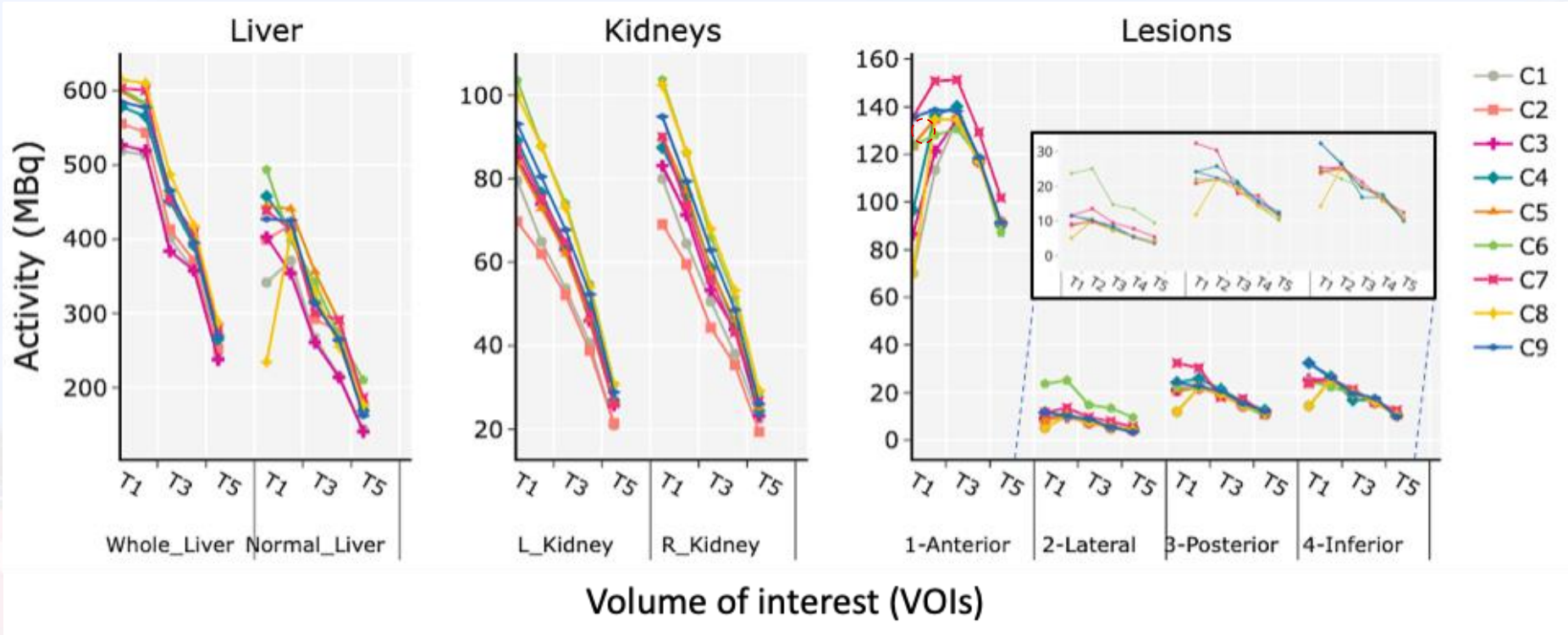
Results (Task 1):

60%



Results (Task 1):

66%

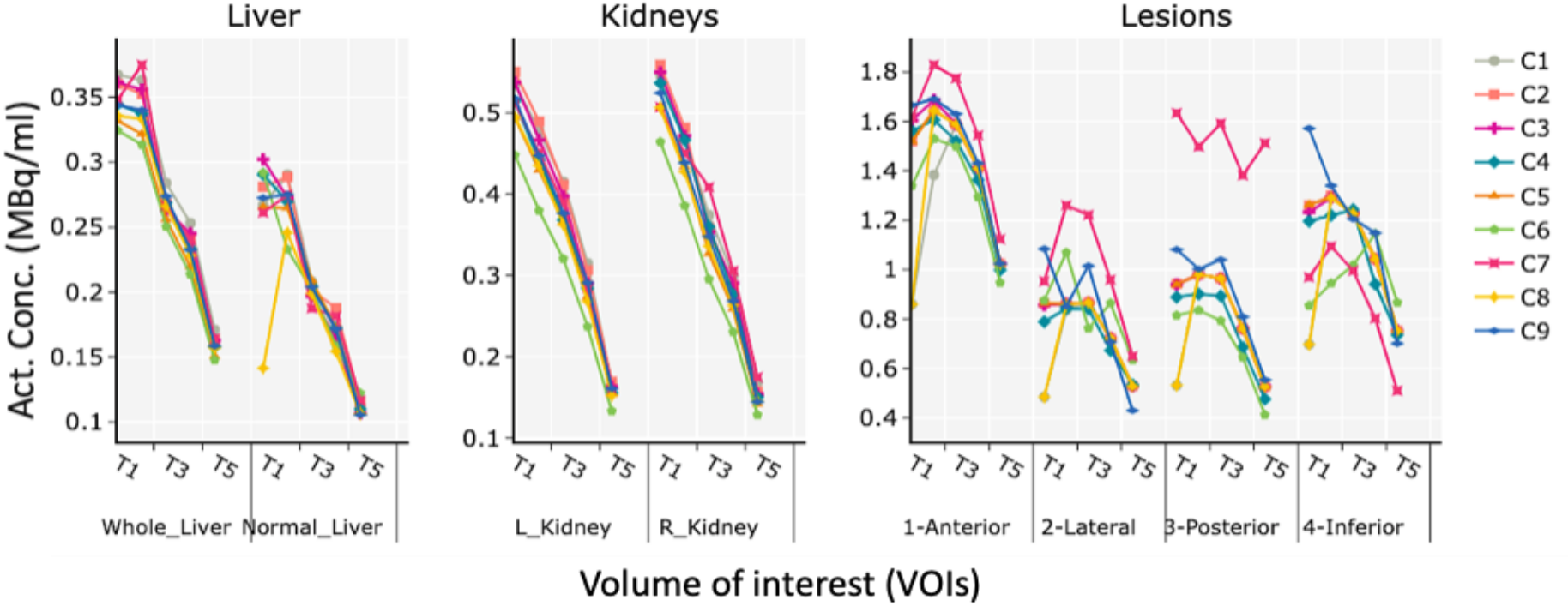


Results (Task 1):

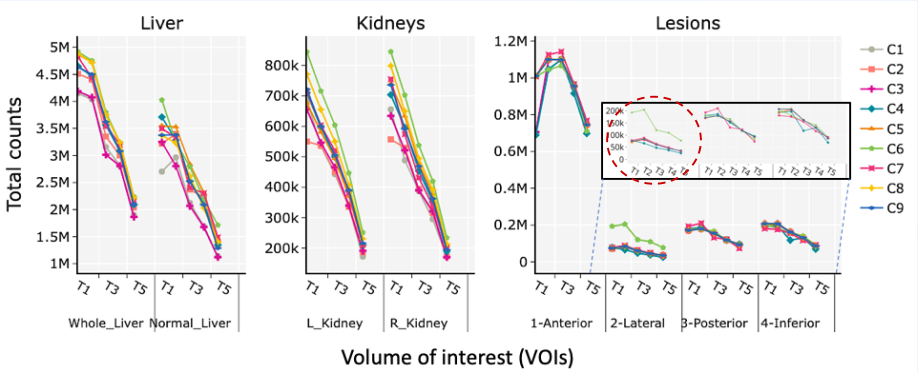
Sources of variations:

- Software misuse
- Unclear software interface
- Some unknown

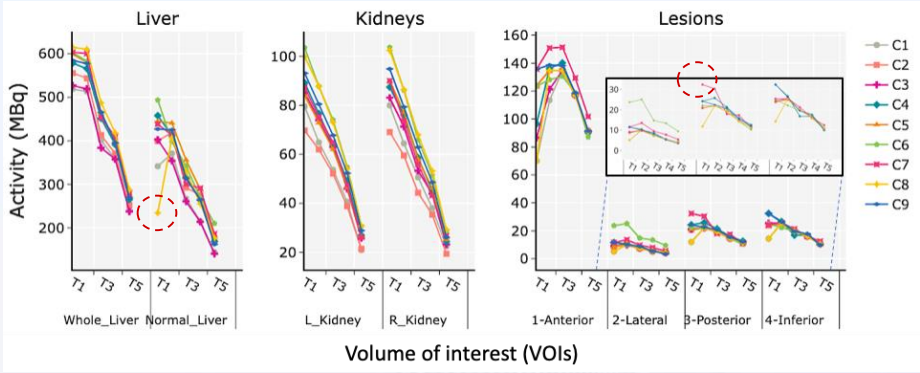
New checkpoint derived ⇒ activity concentration



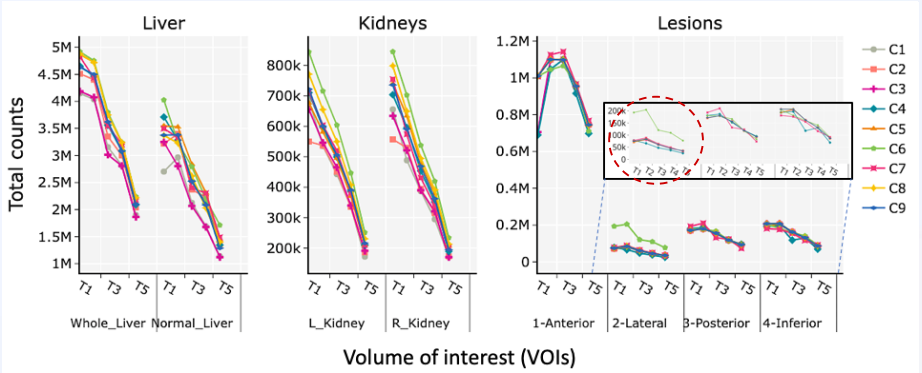
86%


Liver
Kidneys
Lesions
Total counts
5M
4.5M
4M
3.5M
3M
2.5M
2M
1.5M
1M
800k
700k
600k
500k
400k
300k
200k
1.2M
1M
0.8M
0.6M
0.4M
0.2M
0
T1 T3 T5
Whole_Liver
Normal_Liver
L_Kidney
R_Kidney
1-Anterior
2-Lateral
3-Posterior
4-Inferior
C1
C2
C3
C4
C5
C6
C7
C8
C9
Volume of interest (VOIs)

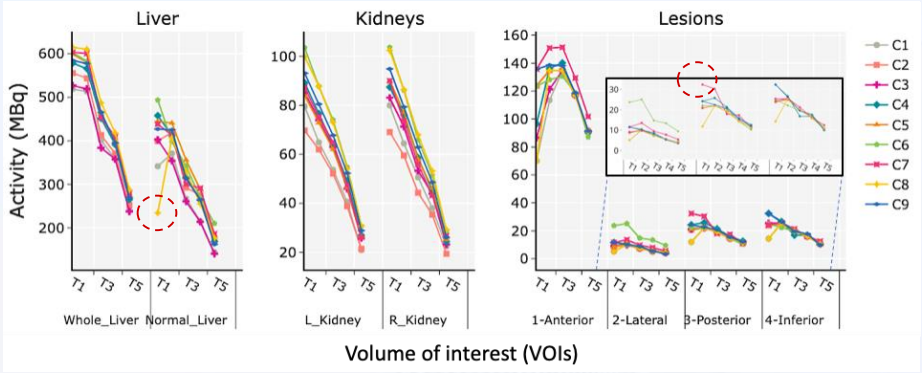
66%


Liver
Kidneys
Lesions
Activity (MBq)
600
500
400
300
200
100
80
60
40
20
160
140
120
100
80
60
40
20
0
T1 T3 T5
Whole_Liver
Normal_Liver
L_Kidney
R_Kidney
1-Anterior
2-Lateral
3-Posterior
4-Inferior
C1
C2
C3
C4
C5
C6
C7
C8
C9
Volume of interest (VOIs)

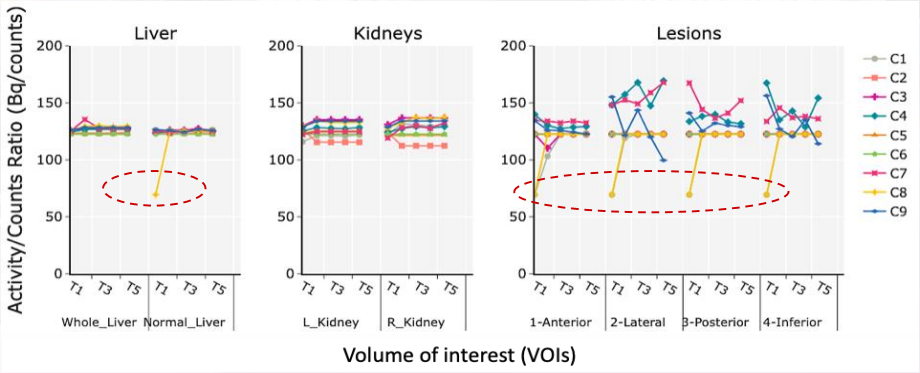
86%



66%

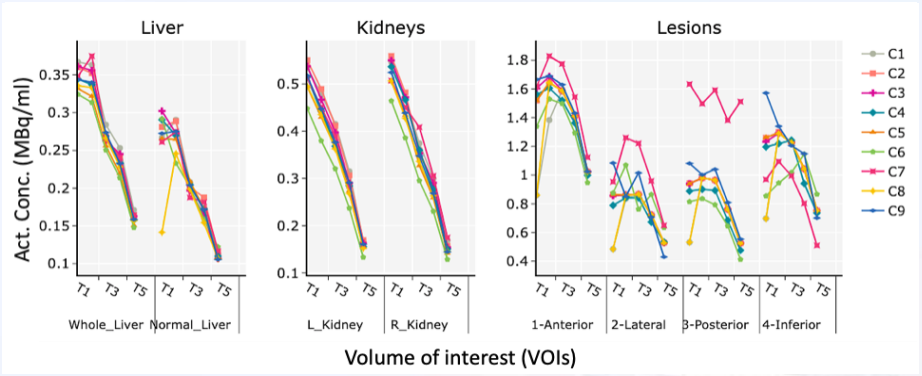


Inconsistencies between counts & activity ⇒ new checkpoint: Activity/counts

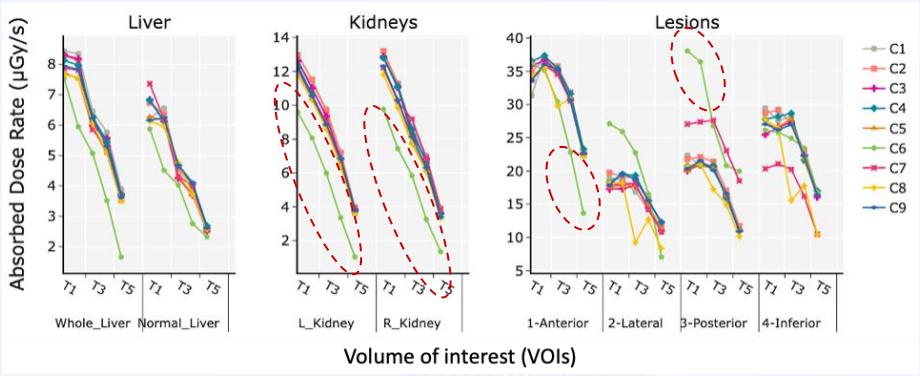


Sources of variations:

- Transcriptional error like wrong data export/ import
- Software misuse

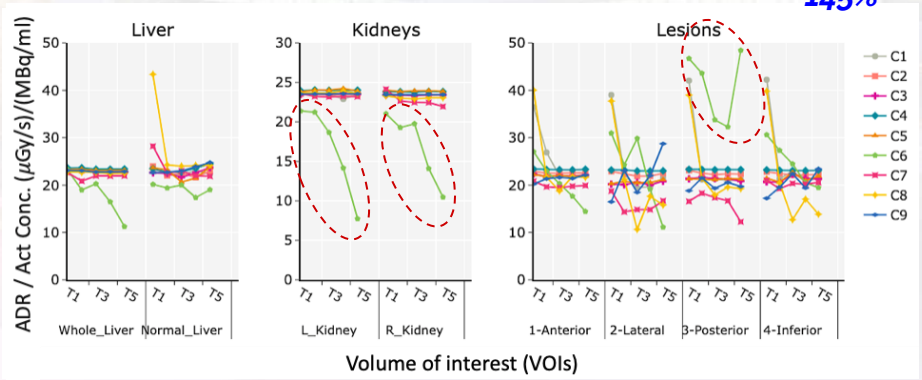


76%

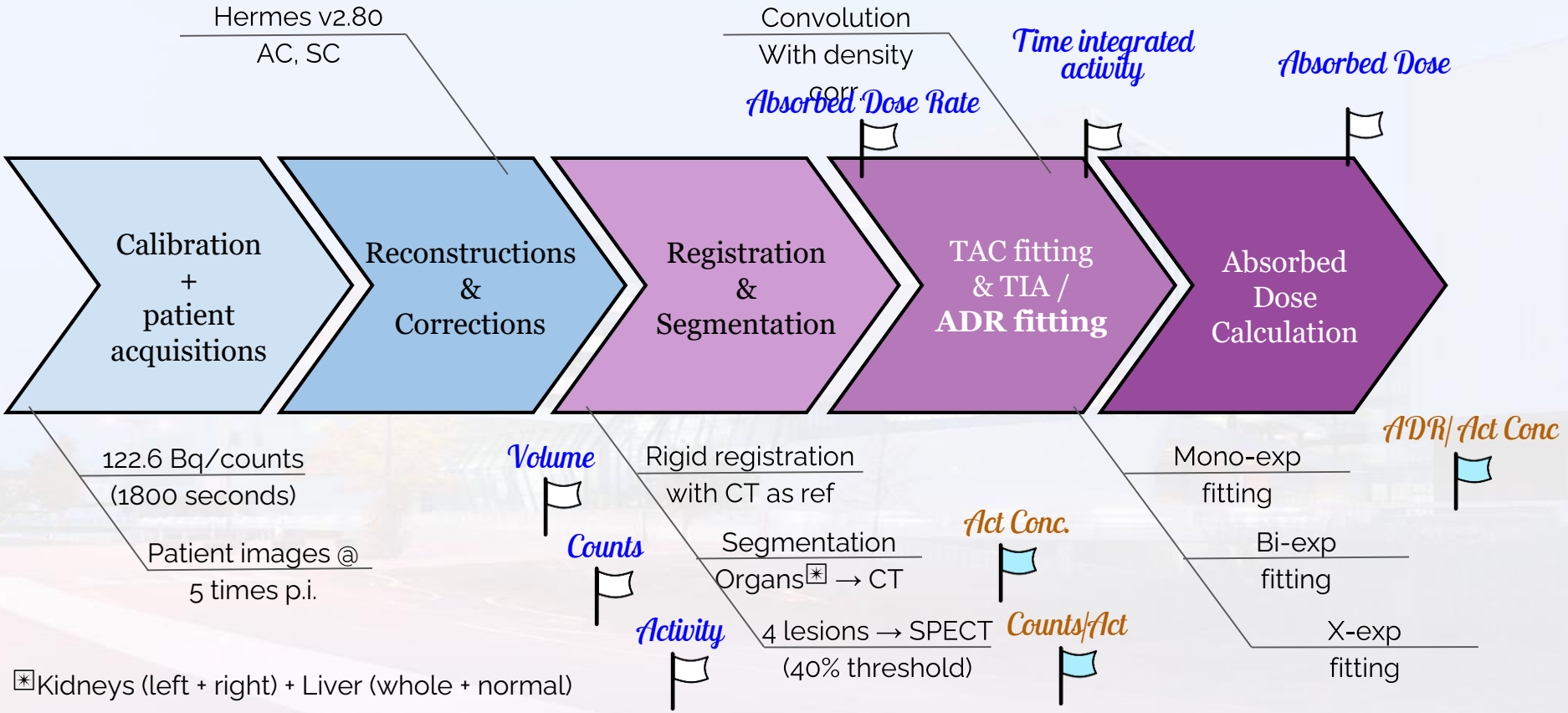


Inconsistencies between ADR & Activity concentration ⇒ new checkpoint

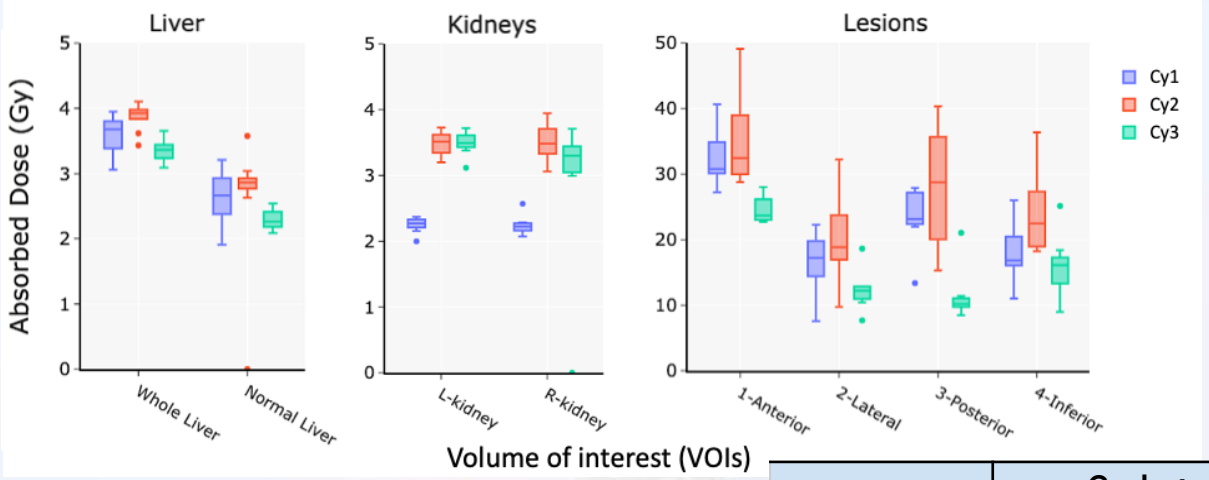
145%



Standard protocol chosen



Absorbed doses (3 cycles)



VOIs	Cycle 1		Cycle 2		Cycle 3	
	Median (Gy)	CoV*	Median (Gy)	CoV	Median (Gy)	CoV
R-kidney	2.22	4.30%	3.49	3.92%	3.32	4.56%
L-kidney	2.27	2.85%	3.51	2.29%	3.49	2.10%
Whole Liver	3.68	2.54%	3.93	2.67%	3.37	4.17%
Normal Liver	2.66	4.18%	2.87	3.54%	2.26	5.35%
1-Anterior	30.81	11.00%	32.45	4.68%	23.70	12.70%
2-Lateral	17.24	17.39%	18.86	9.80%	12.24	33.29%
3-Posterior	23.18	17.73%	28.76	14.27%	10.23	16.68%

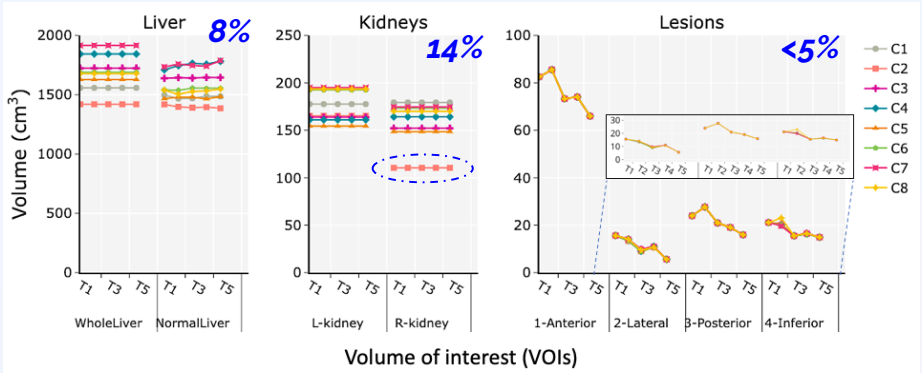
*CoV: coefficient of variation (uncertainty/median)

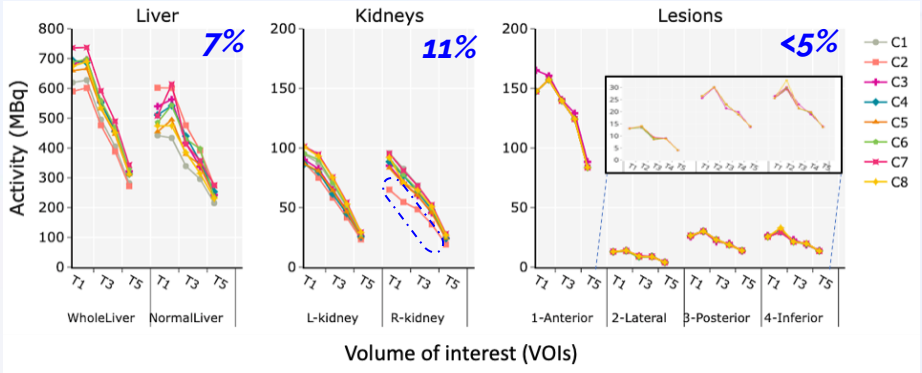
Conclusion (Task 1 - Recommendations)

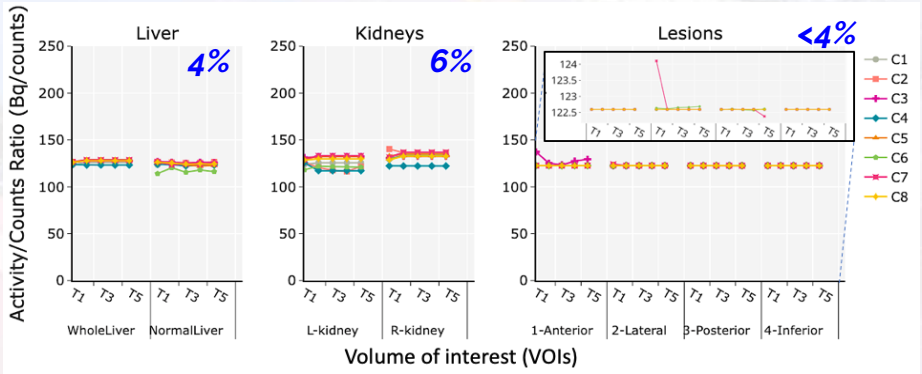
- ***Establishing checkpoints*:** verifying intermediary results at almost every step ⇒ verify the integrity of the data.
- ***Sanity checks in the dosimetry packages*:** Internal checks in the program ⇒ minimize human mistakes ⇒ for example: a warning in software for completely illogical result
- ***Validation of results*:** Cross validation of results among physicists / clinicians or professionals ⇒ minimization of transcriptional errors.
- ***Benchmarked dataset***: For each user to examine their proficiency with the software ⇒ Insight on how precise their results are

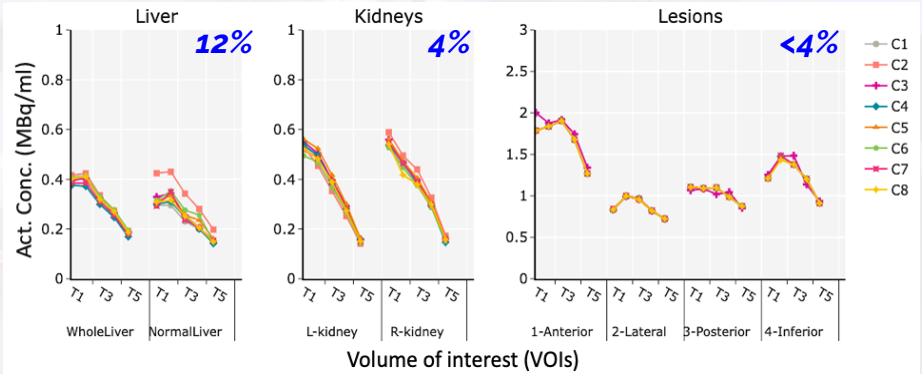
Need for quality assurance in Nuclear Medicine

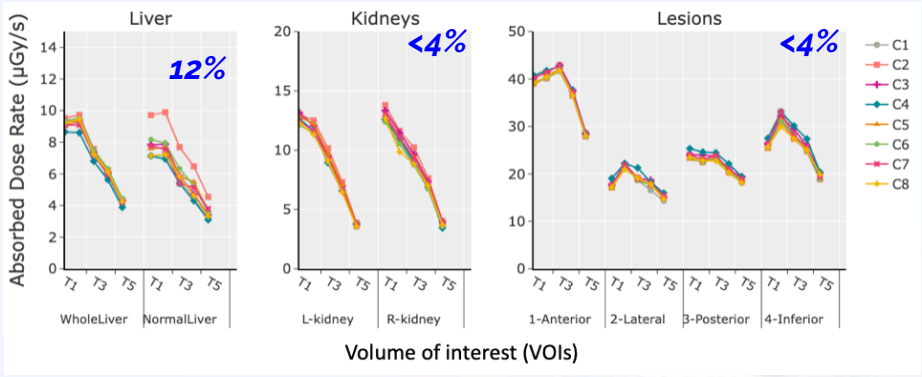
Generating benchmark dataset (Task 2)

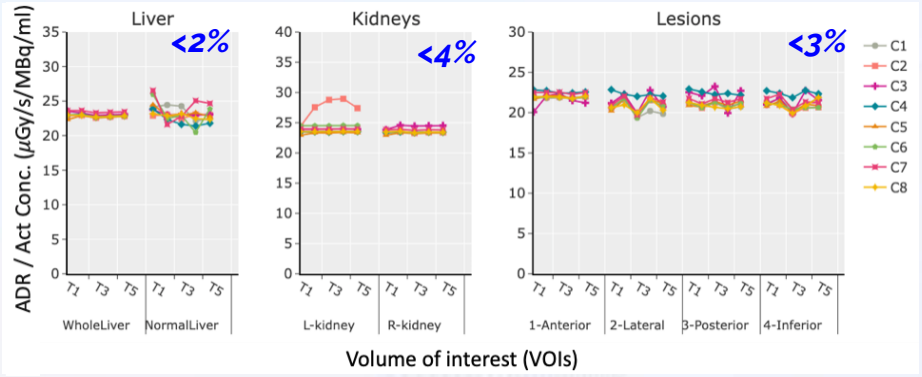


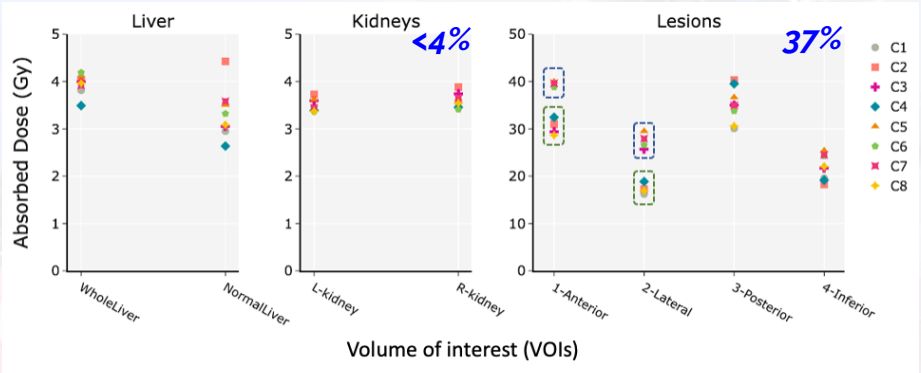


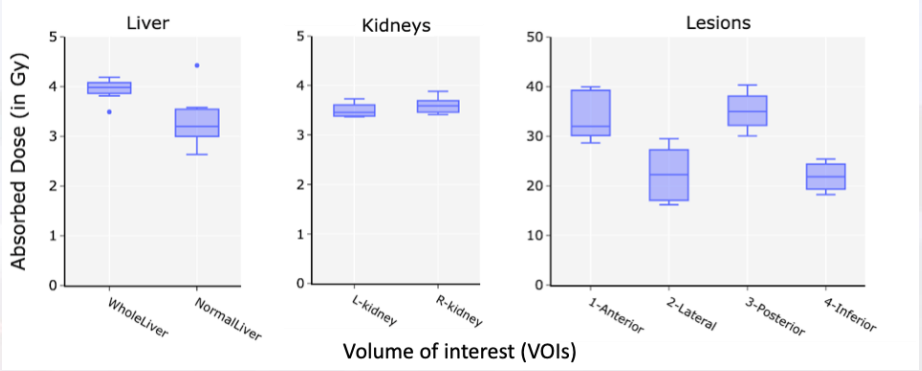












blue : Mono-exp; green : Bi-exp

Lesions:

Variations in AD each fitting group ⇒ <8%; Variation in AD ⇒ 37%

Conclusion (Task 2 - Benchmark Dataset)

This work resulted in the generation of a ***'benchmark dataset'*** consisting of the following:

- reconstructed patient SPECT/CT at five time points
- an associated calibration factor
- a standard workflow to be followed in Planet® Dose
- Step-by-step dosimetry results (with mean and percentage of variation for each established checkpoint)

Will be freely available in IAEA website for individuals to gauge the proficiency of their software (validation & testing)

Thank you!

Questions ??

The patient images used were obtained as a part of *IAEA Coordinated Research Project (CRP) on "Dosimetry in Radiopharmaceutical therapy for personalized patient treatment" (E2.30.05)*.

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