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The consequence of respiratory motion on dose delivery in a mouse lung tumor irradiation using the 4D MOBY phantom

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Introduction

- Small animal models are used in pre-clinical research to investigate cancer characteristics.

- Kilovoltage X-ray irradiators and high resolution CT imaging provide an accuracy improvement in small animal precision radiotherapy.

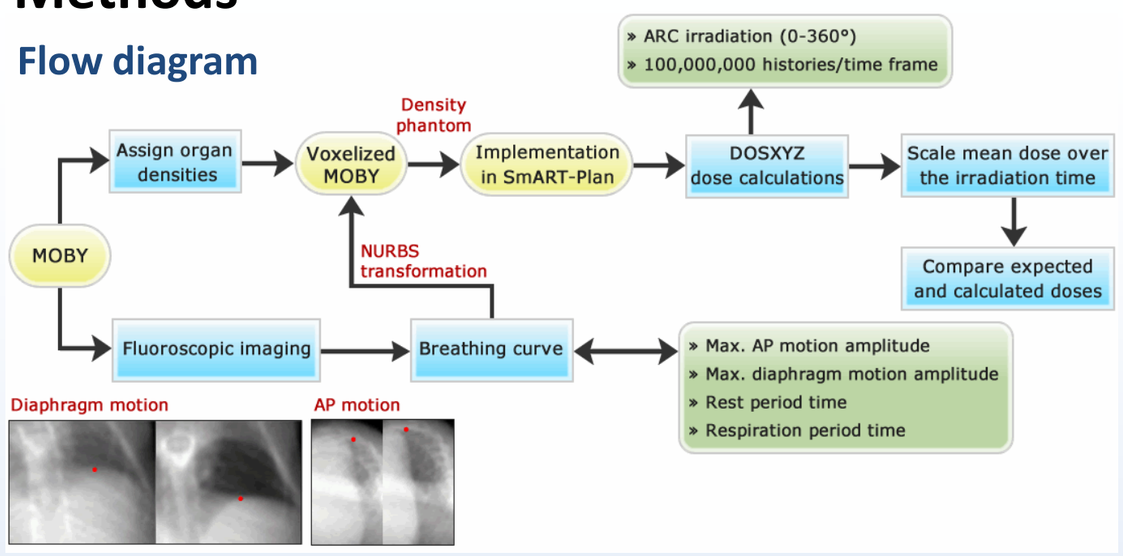
- Respiratory motion during precision irradiation is a concern: the tumor can partially move out of the small irradiation field.

❖ **How can we perform dose calculations on a breathing mouse ?**

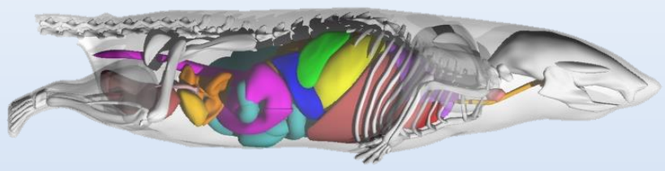
❖ **What is the consequence of respiratory motion on dose delivery in a mouse lung tumor irradiation ?**

Methods

Flow diagram

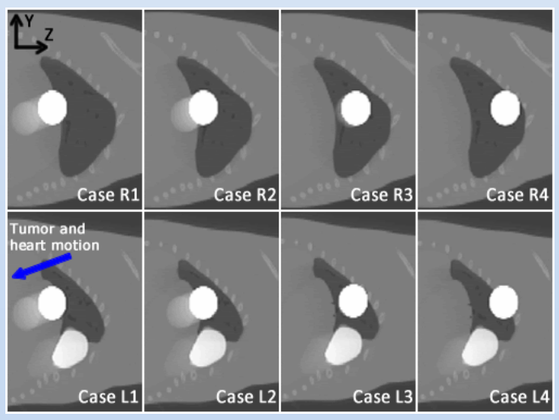


4D digital mouse whole body (MOBY) phantom

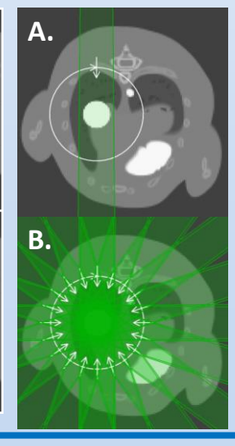


MOBY parameters	
Time resolution	50 ms
Tumor diameter	4 mm
Breathing curve	Anesthetized mouse

MOBY simulation cases



SmART-Plan Small Animal RadioTherapy plan



SmART-Plan settings	
Irradiation plan	360° arc
Collimator diameter	5 mm
Planned target dose	8 Gy

A. 360° arc to calculate mean organ doses

B. 20 beams representing one arc to determine time dependent organ doses

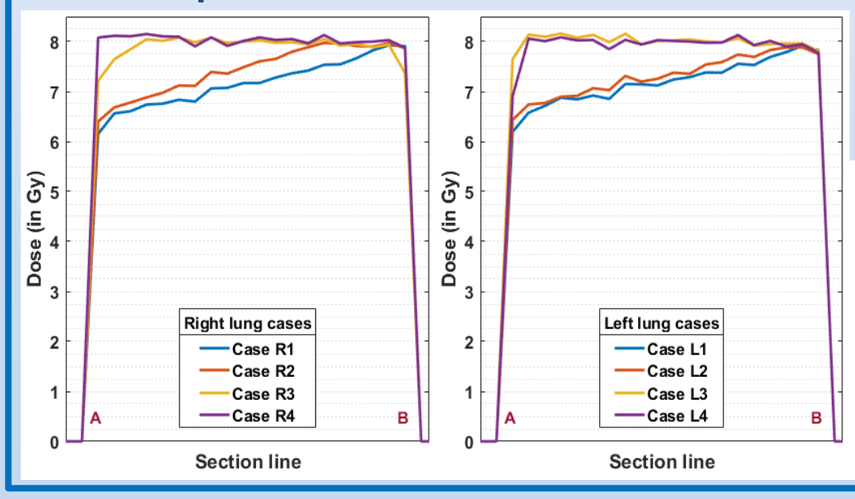
Results

Mean organ doses

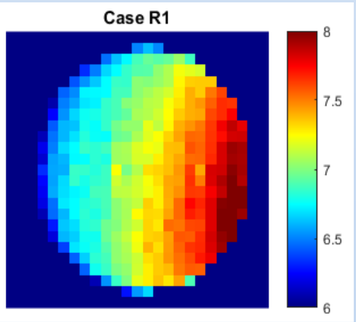
	Expected (Gy)	Obtained (Gy)	Difference %	Expected (Gy)	Obtained (Gy)	Difference %
	Case R1			**Case L1**		
Tumor	7.93	7.09	-11	7.92	7.09	-11
Heart	0.40	0.52	30	0.51	0.64	25
	Case R2			**Case L2**		
Tumor	7.91	7.40	-6	7.91	7.22	-9
Heart	1.18	1.15	-3	1.46	1.40	-4
	Case R3			**Case L3**		
Tumor	7.95	7.89	-1	7.95	7.94	0
Heart	1.30	1.15	-12	1.55	1.36	-12
	Case R4			**Case L4**		
Tumor	7.96	7.96	0	7.94	7.93	0
Heart	0.51	0.44	-14	0.58	0.50	-14

(*) Expected dose = static phantom | Obtained dose = breathing phantom

Time dependent tumor dose



E.g. tumor dose gradient visualization in Case R1.



Conclusion

- The use of MOBY and SmART-Plan provides a suitable method to quantify changes in dose due to respiratory motion in a mouse lung tumor irradiation.

- Some differences between the expected and obtained mean tumor doses are large enough to take into account, especially in cases where the lung tumor is located near the diaphragm.

- State of the art techniques as respiratory gating or motion tracking could provide a proper solution to reduce underdosing of the tumor.

- We recommend assessing the tumor motion before performing small animal precision irradiation.

- In absence of gating or tracking techniques, the use of a suitable beam margin is recommended.

Promotoren / Copromotoren: Prof. Dr. Ir. Frank Verhaegen
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