Multicenter SBRT contouring and planning exercise

Part 1: Introduction

- Goal: explore differences in SBRT practice
- All Belgian RT centers were offered to participate
- 2 cases: SBRT spine and SBRT central lung

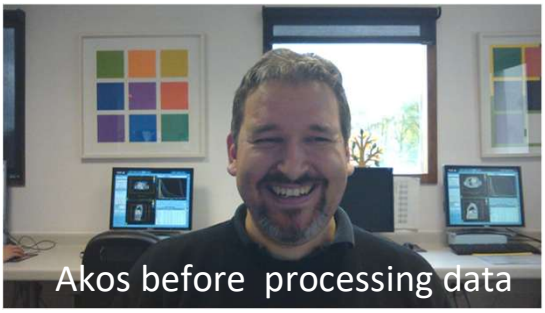
Contouring exercise	Creating consensus contour	Planning exercise
We provided: - Case information - DICOM image sets - template with structures to contour 12 centers returned 2 contour sets and prescription propositions	1 Contour set to rule them all	- Identical prescription dose - Identical OAR constraints - Room for differences in heterogeneity 12 centers returned 2 treatment plans

Presentation outline

01	Introduction	
02	Spine Case	• Contouring • Planning • Discussion
03	Lung Case	• Contouring • Planning • Discussion

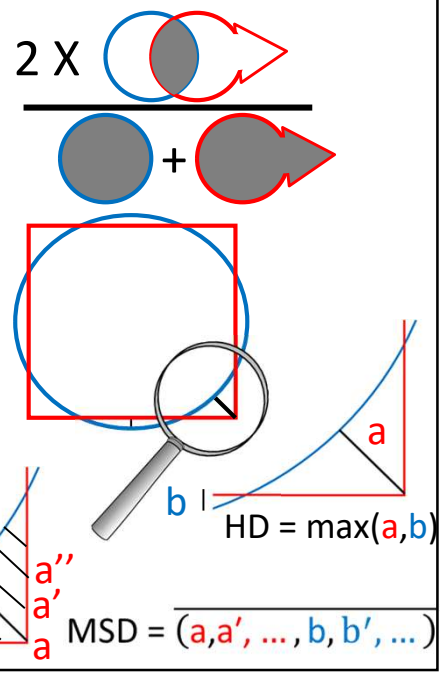
First thoughts

- We did it!
  - Many centers cooperated
  - Technically feasible
- Special thanks to Akos
- Still, some challenges (integrating DICOM RTplan information…)



Akos before processing data

Calculate	What it tells you:
Dice Similarity Coefficient (DSC)	***How much do they overlap*** 👉DSC = 1 (perfect match) 👉DSC = 0 (completely different) As to be evaluated in a relative way
95% Hausdorff Distance (HD95)	***Worst (but not outlier) edge-to-edge distance*** Because one weird dot can ruin it ➡ Exclude the largest 5% 👉The shorter the better
Mean Surface Distance (MSD)	***Average edge-to-edge distance*** 👉The shorter the better



Part 2: SPINE CASE

Short history: Female patient of 47 years old with a synchronous oligometastatic breast cancer

04/2023: Diagnosis of a left breast cancer, and unique osteolytic lesion at T1 vertebra. cT2N0M1

02/05/2023: Initiated treatment with letrozole, goserelin, ribociclib.

21/12/2023: Left mastectomy + sentinel procedure and reconstruction with prosthesis.

05/02/2024 – 23/02/2024: Radiotherapy: 40.05 Gy in 15 fractions to the left chest wall.

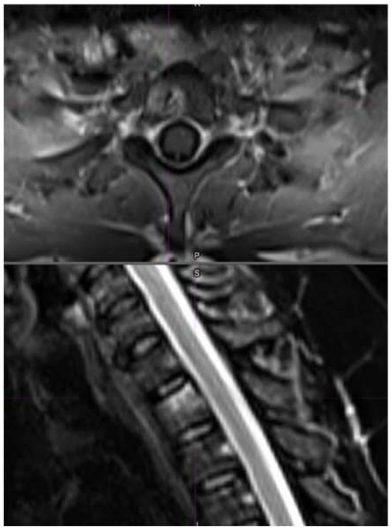
Continue letrozole, goserelin, ribociclib.

30/07/2024: Mild pain at T1-T2 level. Follow-up PET-FDG: Metabolic reactivation of the osteolytic lesion in the T1 vertebral body. No other hypermetabolic lesions suggestive of progression.

05/08/2024: MRI total spine: confirmed unique metastatic lesion at the posterior side of the vertebral body of T1.

06/08/2024: Tumor board decision: SBRT to the T1 metastasis and continue letrozole, goserelin, ribociclib.

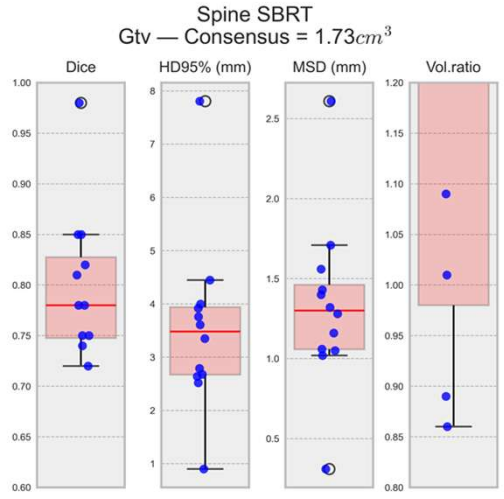
Provided images: CT and MRI



GTV (1 outlier)

All GTVs compared to each other

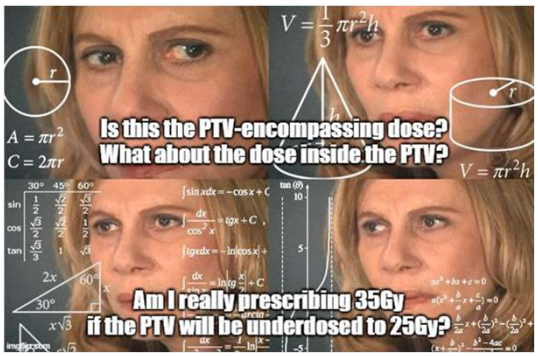
All GTVs compared to consensus GTV



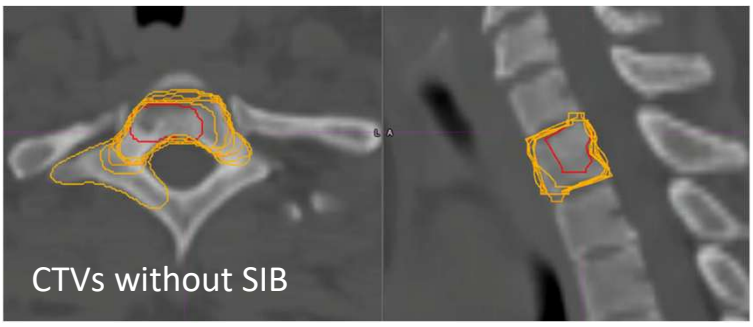
Proposed treatment schedules

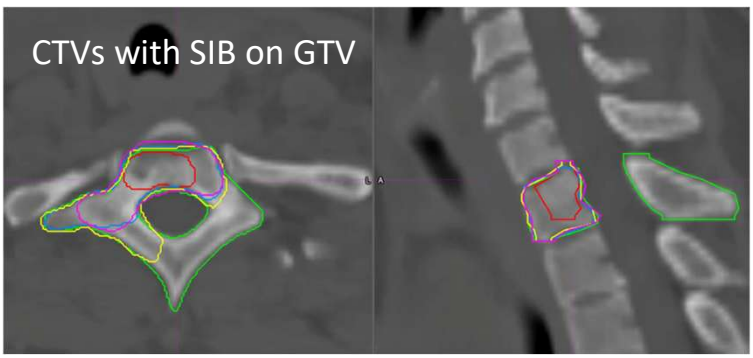
- 5 x 7 Gy (3 centers)
- 5 x 6 Gy (2 centers)

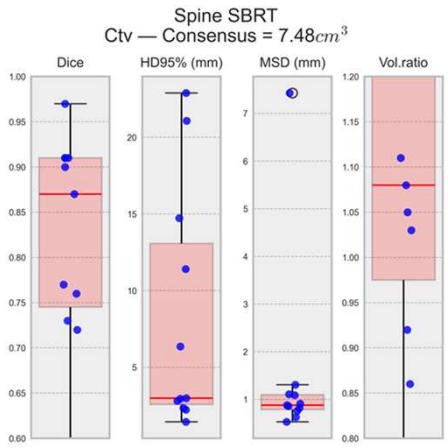
- 3 x 10 Gy (1 center)
- 3 x 9-10 Gy (1 center)
- 3 x 8 Gy @ 80% (1 center)

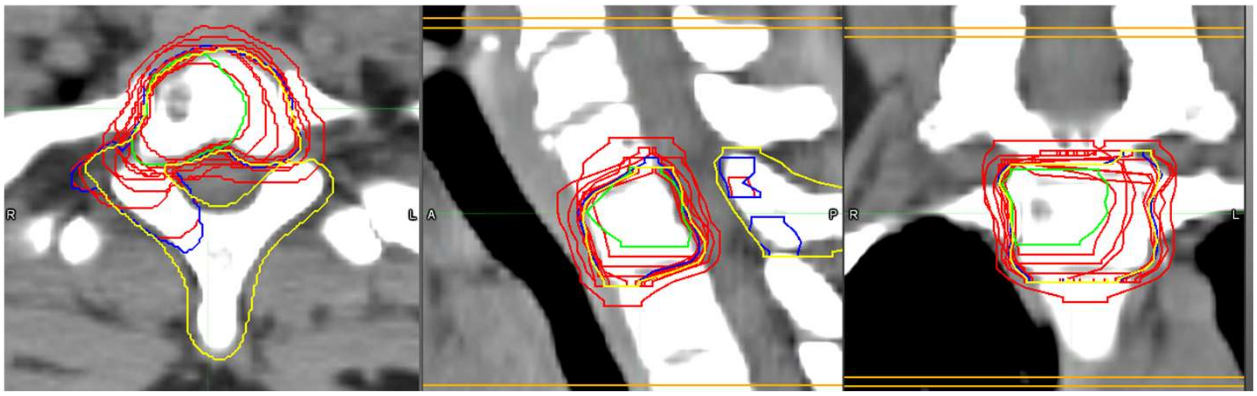


- SIB approach (boost on GTV +/- PTV-margin) (4 centers)
  - 5 x 7 Gy / 5 x 4 Gy
  - 3 x 10 Gy / 3 x 6 Gy
  - 3 x 10 Gy / 3 x 7 Gy
  - 2 x 12 Gy / 2 x 6 Gy

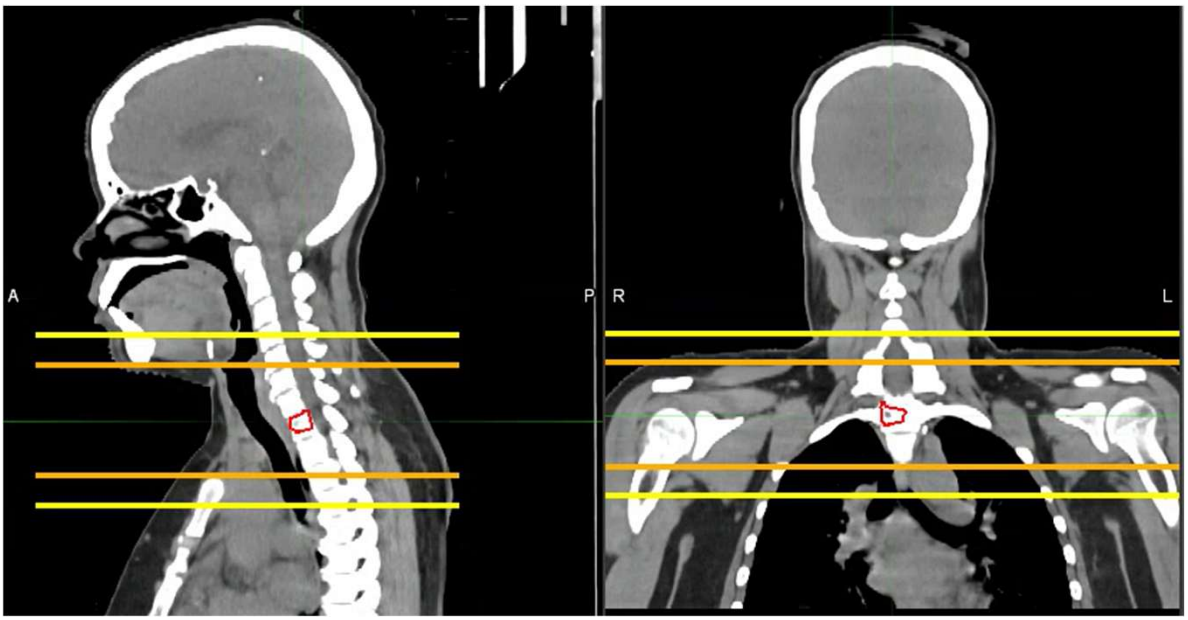




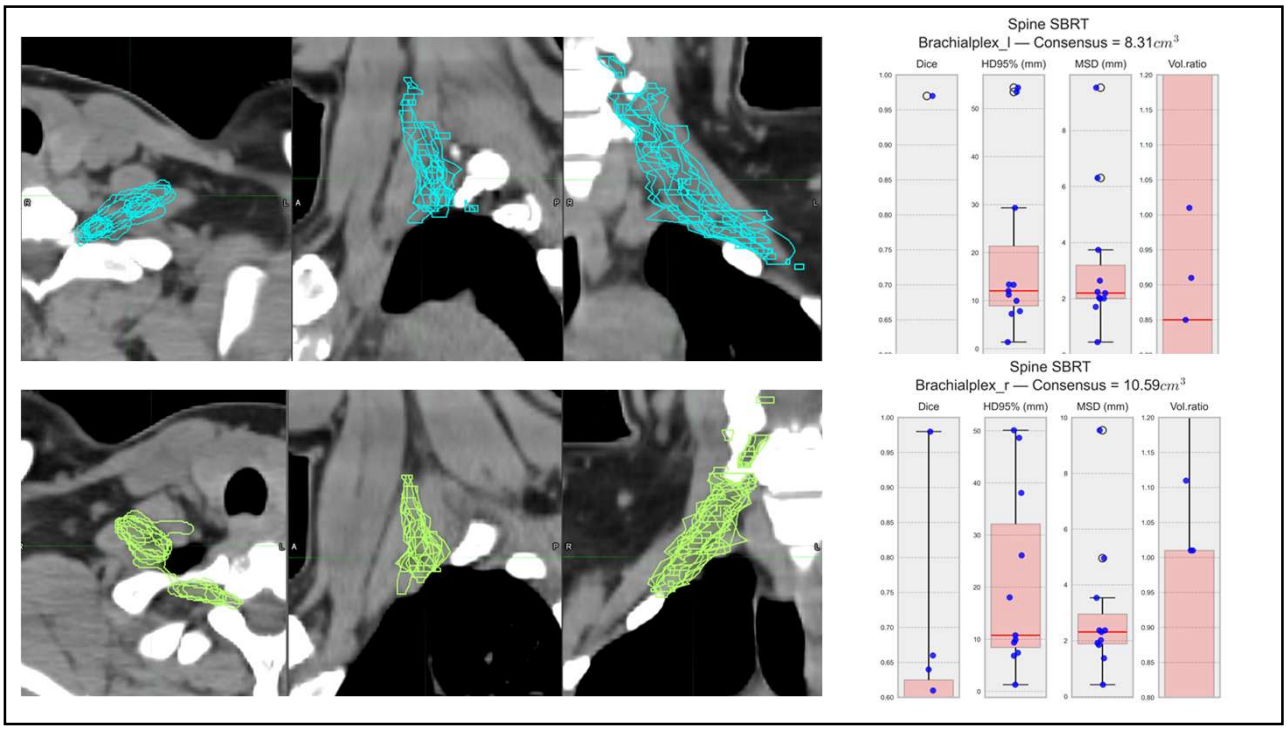


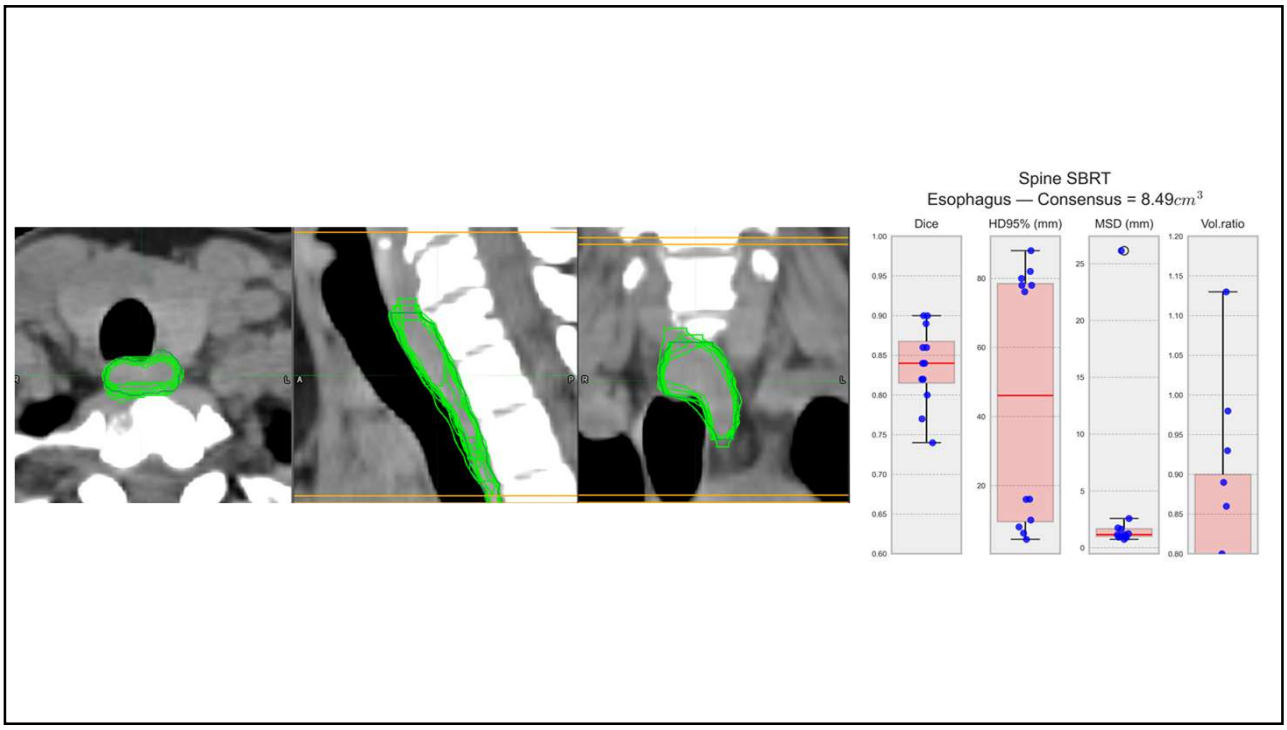


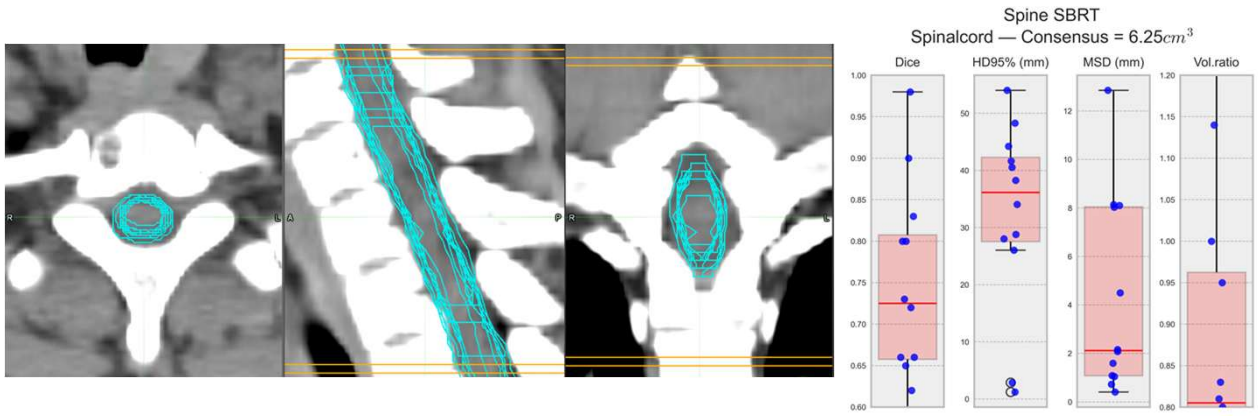
PTVS (3 SIB PTVs included)



OARs were cropped 3 cm above and below the consensus GTV


Spine SBRT
Brachialplex_l — Consensus = 8.31cm^3
Dice
HD95% (mm)
MSD (mm)
Vol.ratio
Spine SBRT
Brachialplex_r — Consensus = 10.59cm^3
Dice
HD95% (mm)
MSD (mm)
Vol.ratio


Spine SBRT
Esophagus — Consensus = 8.49cm^3
Dice
HD95% (mm)
MSD (mm)
Vol.ratio



Part 2B. Spine case planning

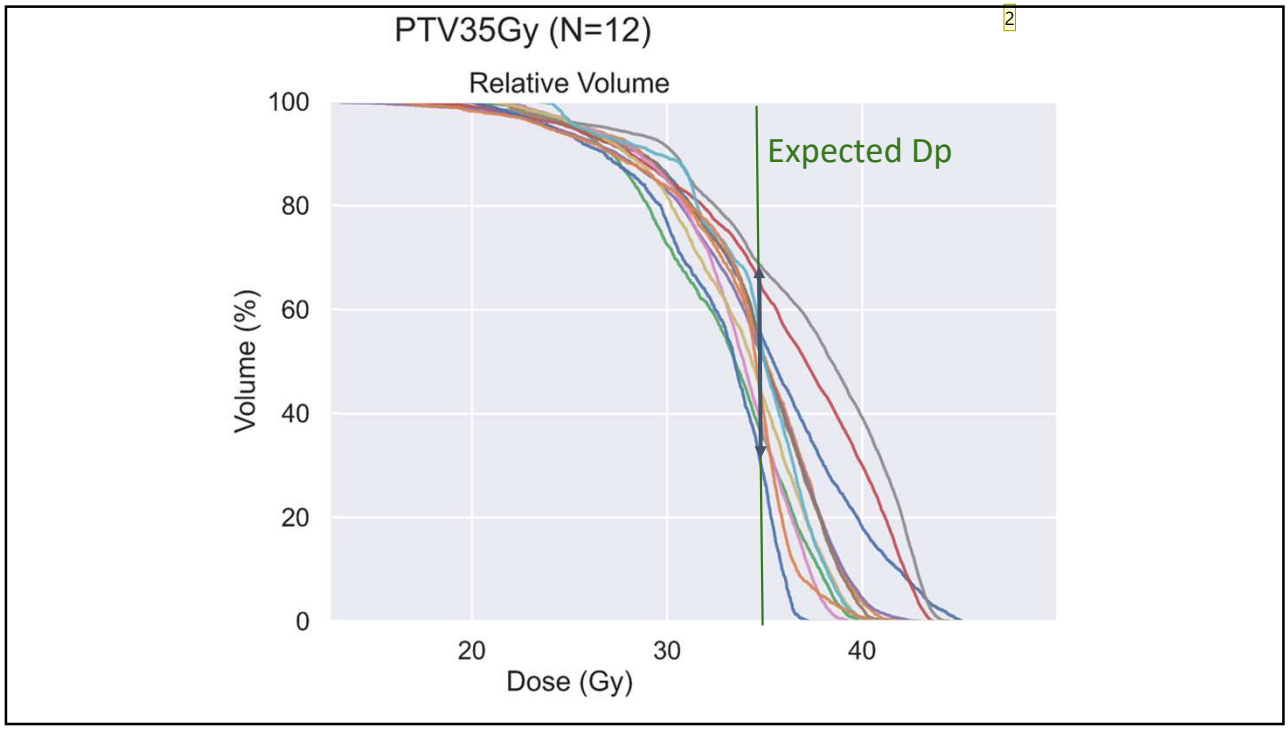
- Identical contours
- Identical prescription
- Identical OAR constraints

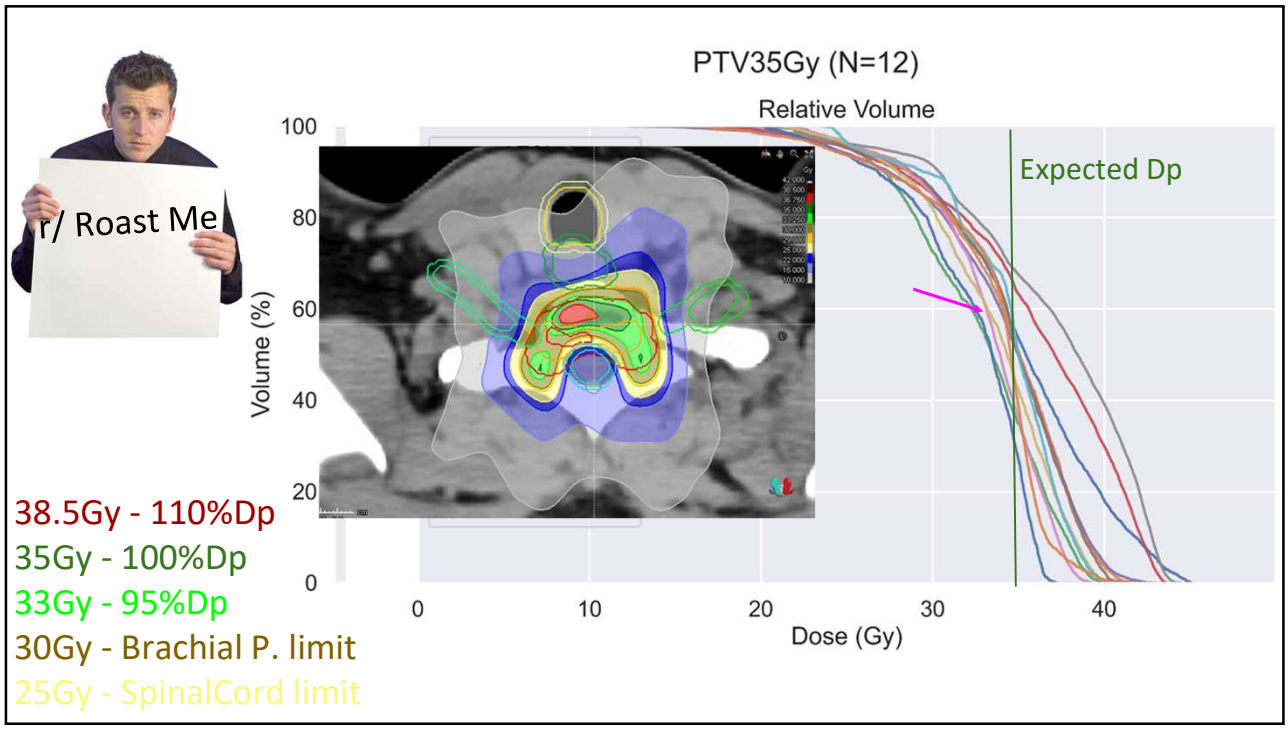
Prescription:

- 35 Gy in 5 fractions
- Target objective (while respecting OAR mandatory constraints):
  - Maximize PTV coverage with prescription dose
  - Ideal PTV coverage (D95% > 35 Gy)

OAR Dose contraints SBRT 35 Gy / 5 Fr:

OAR	Mandatory	Optimal
Chest wall	D0.1cc < 105 %	V30Gy < 30 cc
Esophagus PRV	D0.1cc < 35 Gy	
Spinal Cord PRV	D0.1cc < 25.3 Gy	
Brachial Plexus PRV	D0.1cc < 32 Gy	D0.1cc < 30.5 Gy
Brachial Plexus PRV	D3cc < 30 Gy	D3cc < 27 Gy
Trachea and Bronchus PRV	D5cc < 32 Gy	
Trachea and Bronchus PRV	D0.1cc < 38 Gy	


PTV35Gy (N=12)
Relative Volume
Expected Dp
Volume (%)
100
80
60
40
20
0
20
30
40
Dose (Gy)


r/ Roast Me
PTV35Gy (N=12)
Relative Volume
Expected Dp
Volume (%)
100
80
60
40
20
0
0
10
20
30
40
Dose (Gy)
38.5Gy - 110%Dp
35Gy - 100%Dp
33Gy - 95%Dp
30Gy - Brachial P. limit
25Gy - SpinalCord limit

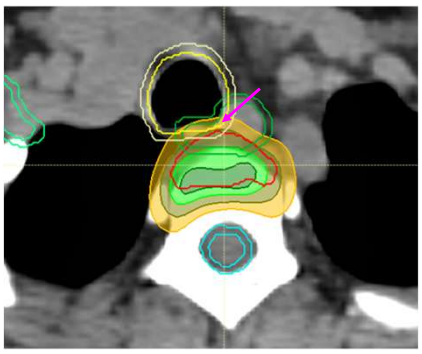
Dia 17

1 Very nice to show here that despite identical contours, prescription and constraints, planned dose is wildly different!
Robbe Van den Begin; 9-10-2025

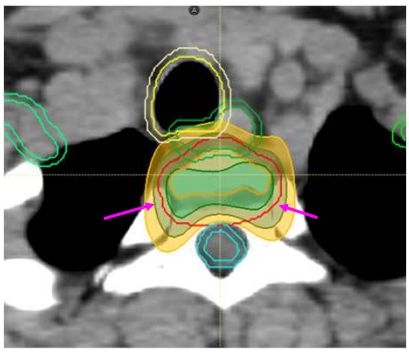
2 Also, is this still a prescription of 35Gy? Link to the discussion of Saturday
Robbe Van den Begin; 9-10-2025

How to improve ?

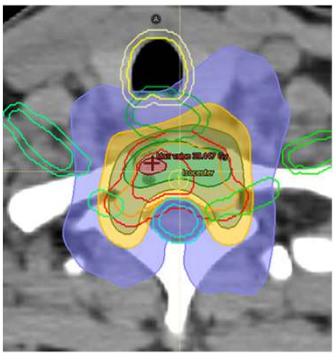
Homogeneous dose at Esophagus intersection



Edges coverage

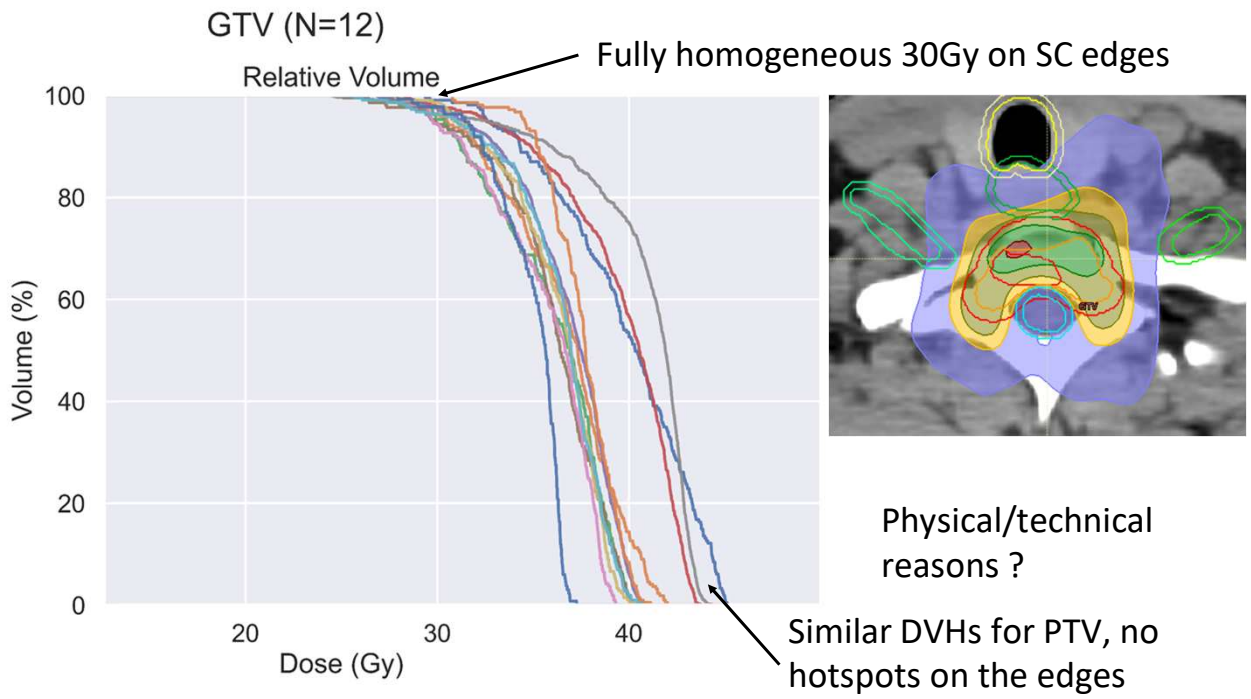


Increased dose gradient



38.5Gy - 110%Dp 35Gy - 100%Dp 33Gy - 95%Dp
30Gy - Brachial P. limit 25Gy - SpinalCord limit

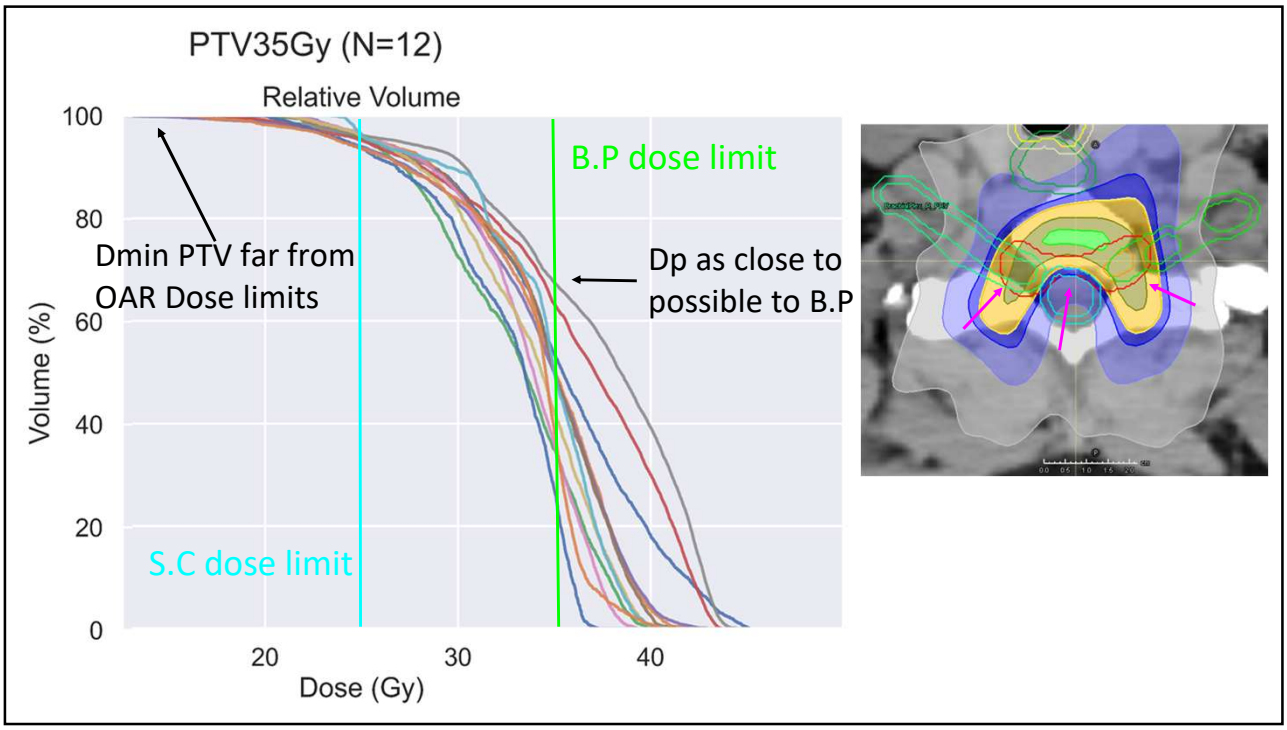
Tip: small structure = higher impact in the optimizer



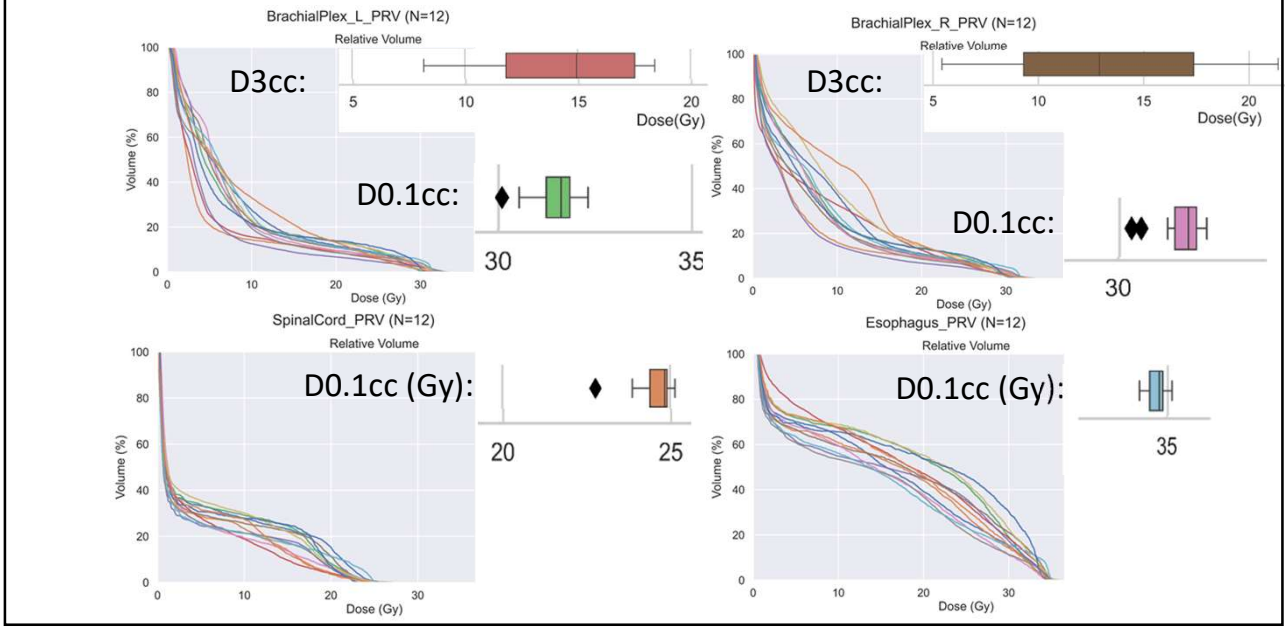
Fully homogeneous 30Gy on SC edges

Physical/technical reasons ?

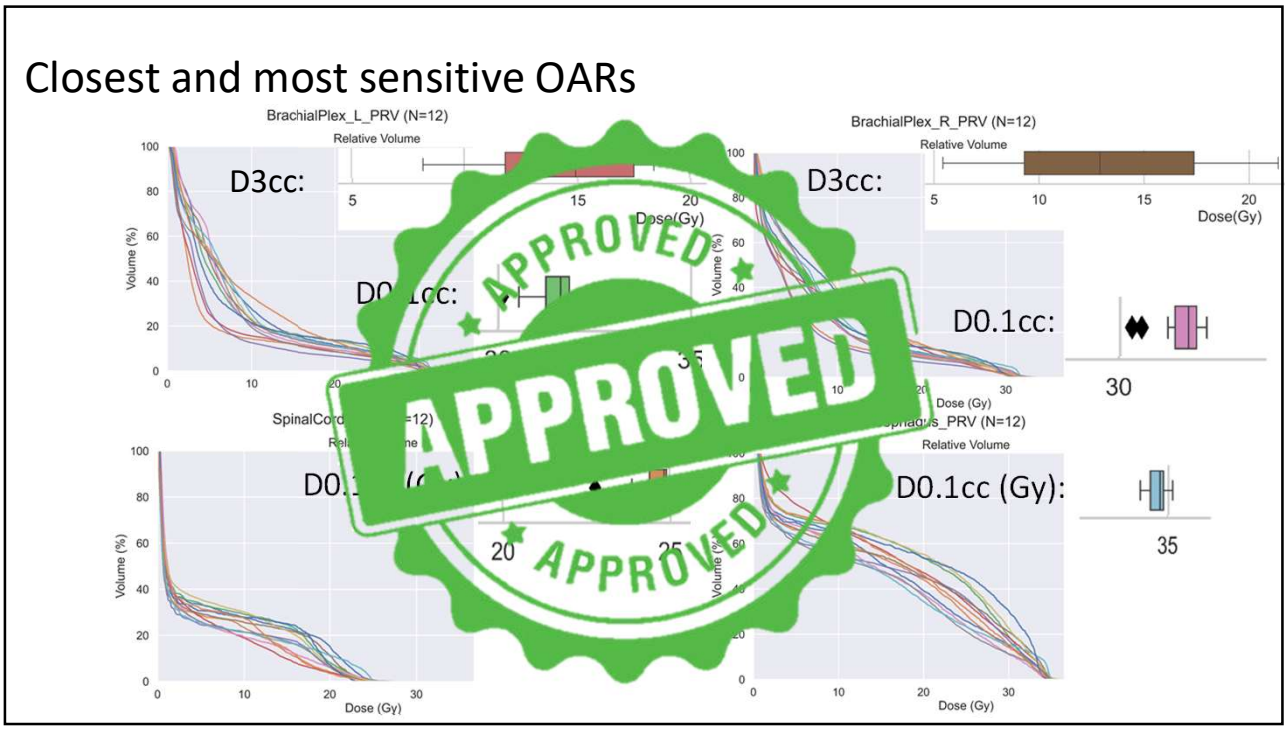
Similar DVHs for PTV, no hotspots on the edges

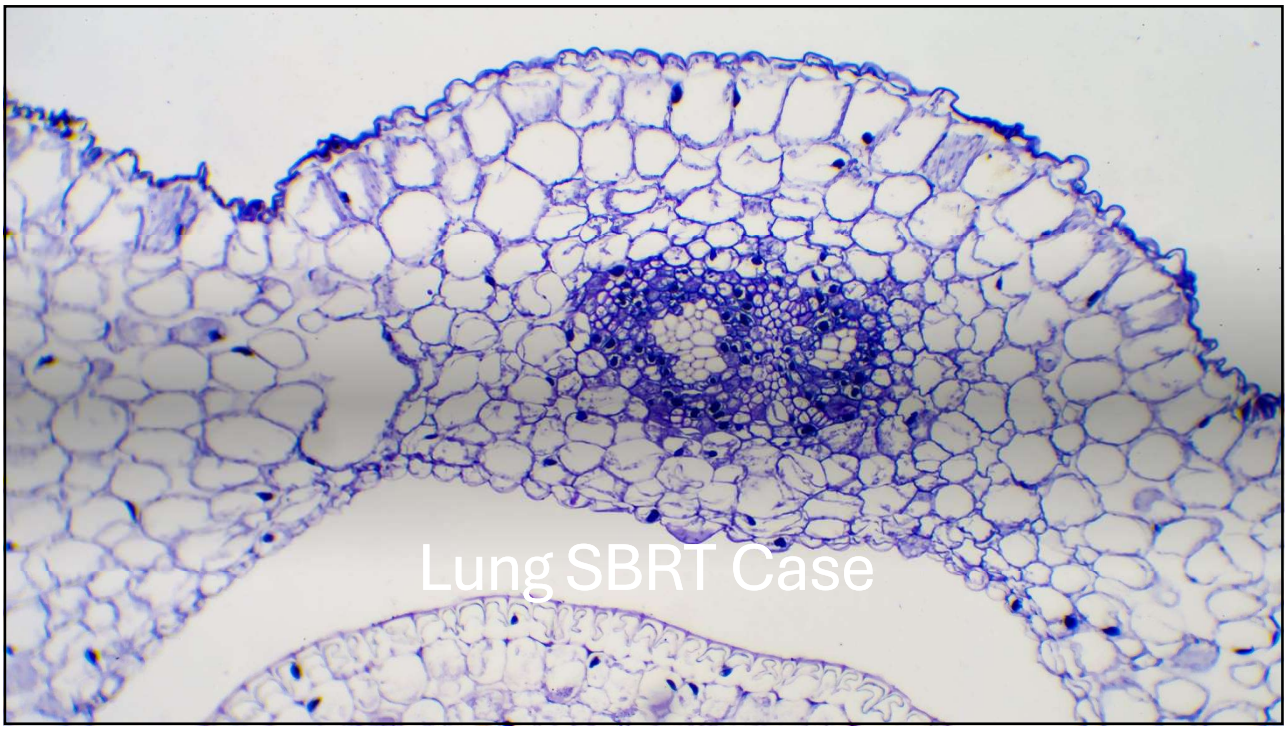


Closest and most sensitive OARs



Closest and most sensitive OARs





PYTHON SCRIPT

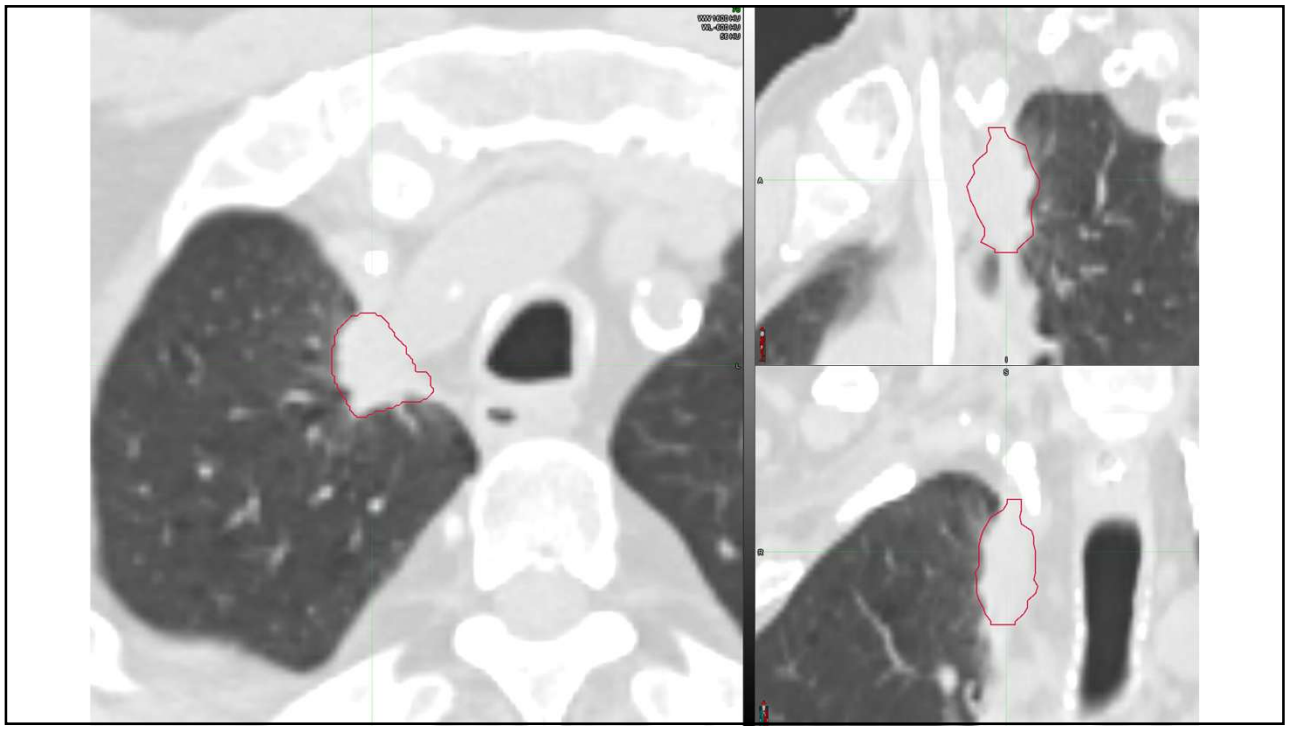
AKOS

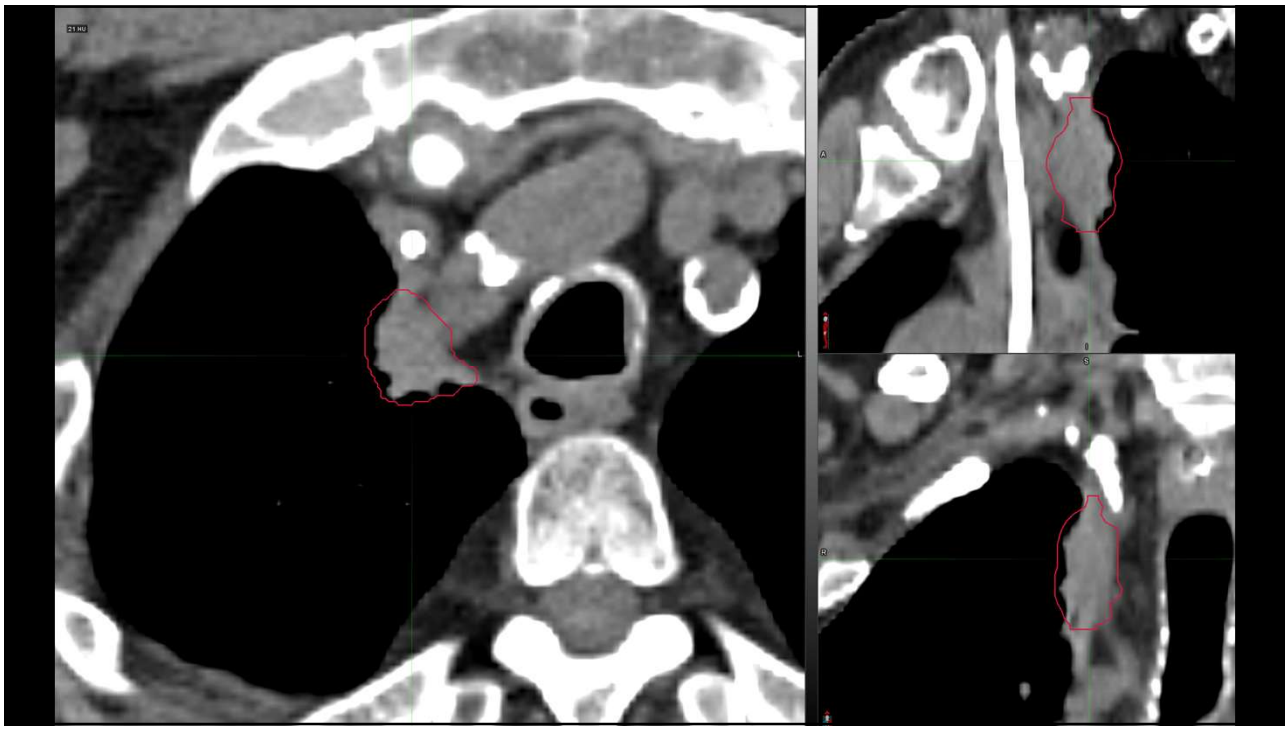
78 year old male

- **Imaging.** PET-CT: hypermetabolic lesion in the right upper lung lobe, consistent with a primary pulmonary neoplasm. Suspicious uptake noted in mediastinal lymph nodes.
- **Diagnostic Workup:**
  - **EBUS-TBNA:** Confirmed diagnosis of pulmonary adenocarcinoma, PD-L1 expression at 90%.
  - **Staging via EBUS (stations 11L, 4L, 7L, 4R, 11R):** no evidence of nodal metastasis.
- **Clinical Stage:** cT2N0M0

Multidisciplinary Tumor Board Decision:

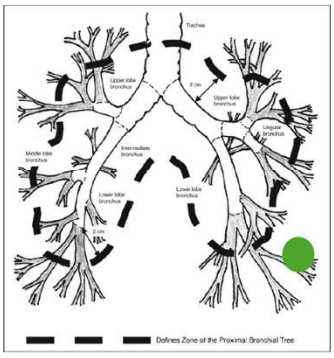
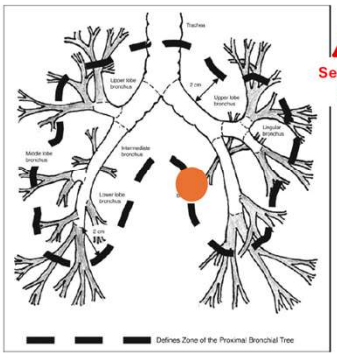
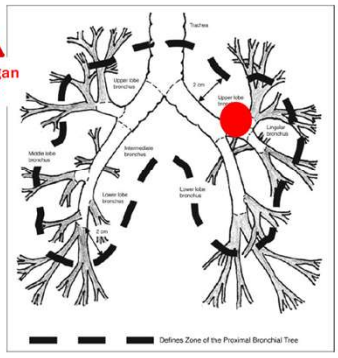
- Patient deemed medically inoperable due to comorbidities and functional status.
- **Recommended Treatment:** SBRT (curative intent).






7 mm

Dose prescription

PERIPHERAL Outside no-fly zone	CENTRAL Within no-fly zone	ULTRA-CENTRAL Abbuting PBT, oeso, mediastin
		
3x18 Gy – 4x12 Gy – 5x11 Gy $D_{95\%} = D_{prescribed}$ D_{max}: 125-150% (within GTV)	8x7.5 Gy $D_{95\%} = D_{prescribed}$ D_{max}< 120%, no endobronchial tumor OARs constraints prioritized over PTV	8x7.5 Gy – 60 Gy in 10, 12 or 15# $D_{95\%} = D_{prescribed}$ D_{max}< 120%, no endobronchial tumor OARs constraints prioritized over PTV

Serial organ ahead

Indication › Motion › Simulation › Delineation › **Planning** › IGRT › Outcome

Lung case: survey on dose prescription

77%

≤ 8 fractions

- **69%** **60 Gy in 8 fractions** (9 centers)
- 7.7% 50 Gy in 5 fractions (1 center)

23%

≥ 15 fractions

- 15 fractions
  - 60 Gy in 15 fractions (1 center)
  - 51 Gy in 15 fractions (1 center)
- 24 fractions
  - 66 Gy in 24 fractions (1 center)

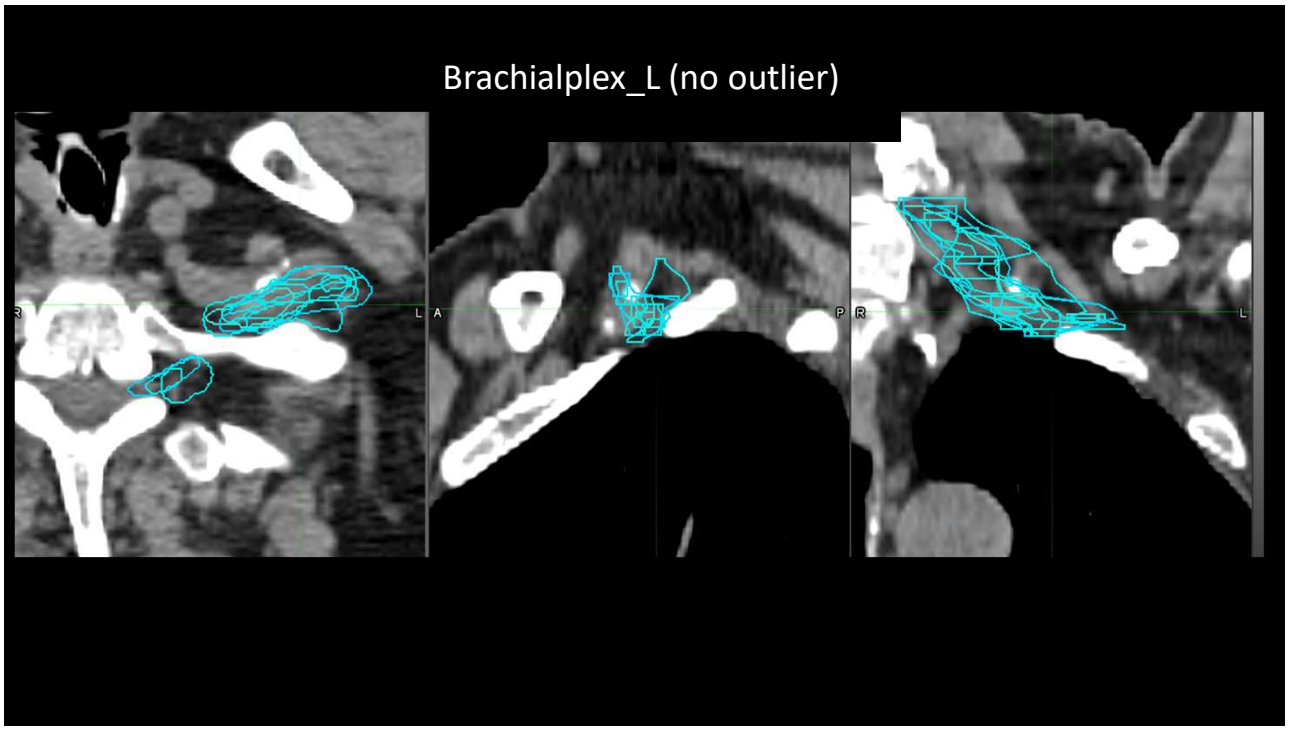
	≤ 8 fractions	≥ 15 fractions
Academic centers (n=5)	**All (100%)**	None (0%)
Non-academic centers (n=8)	62.5%	37.5%

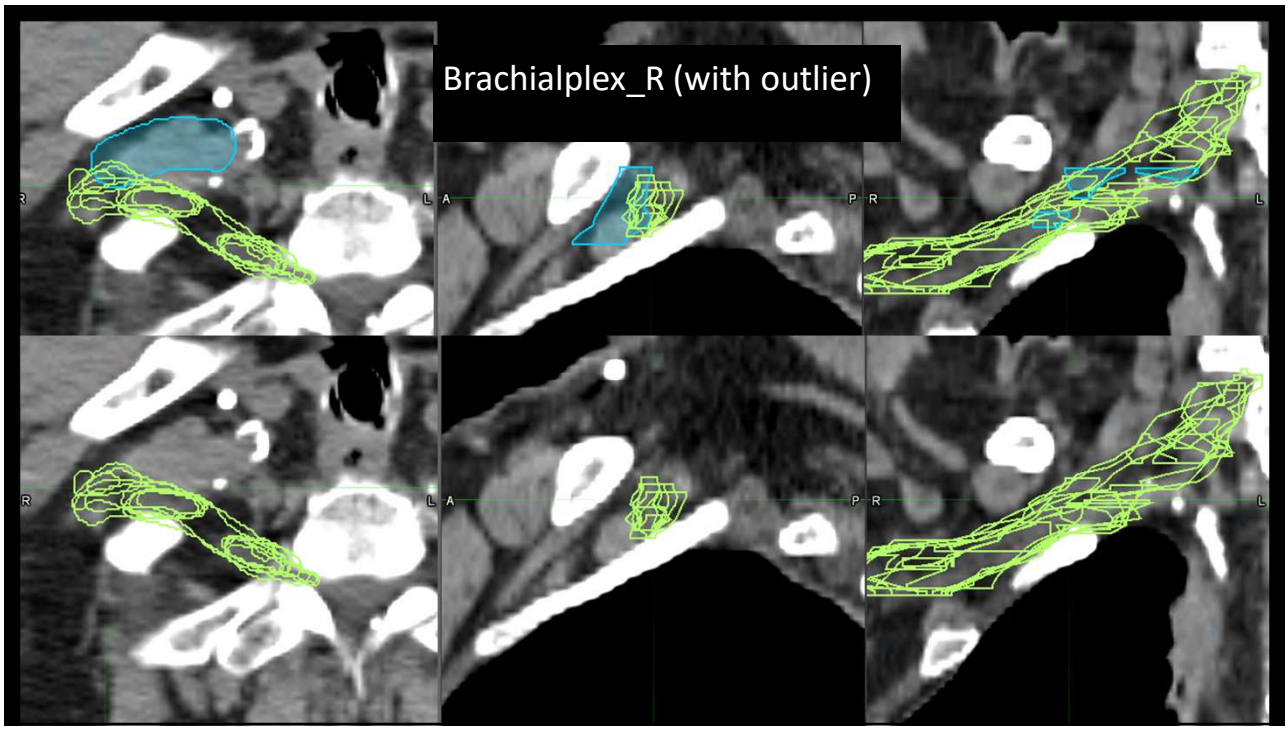
Contouring Task

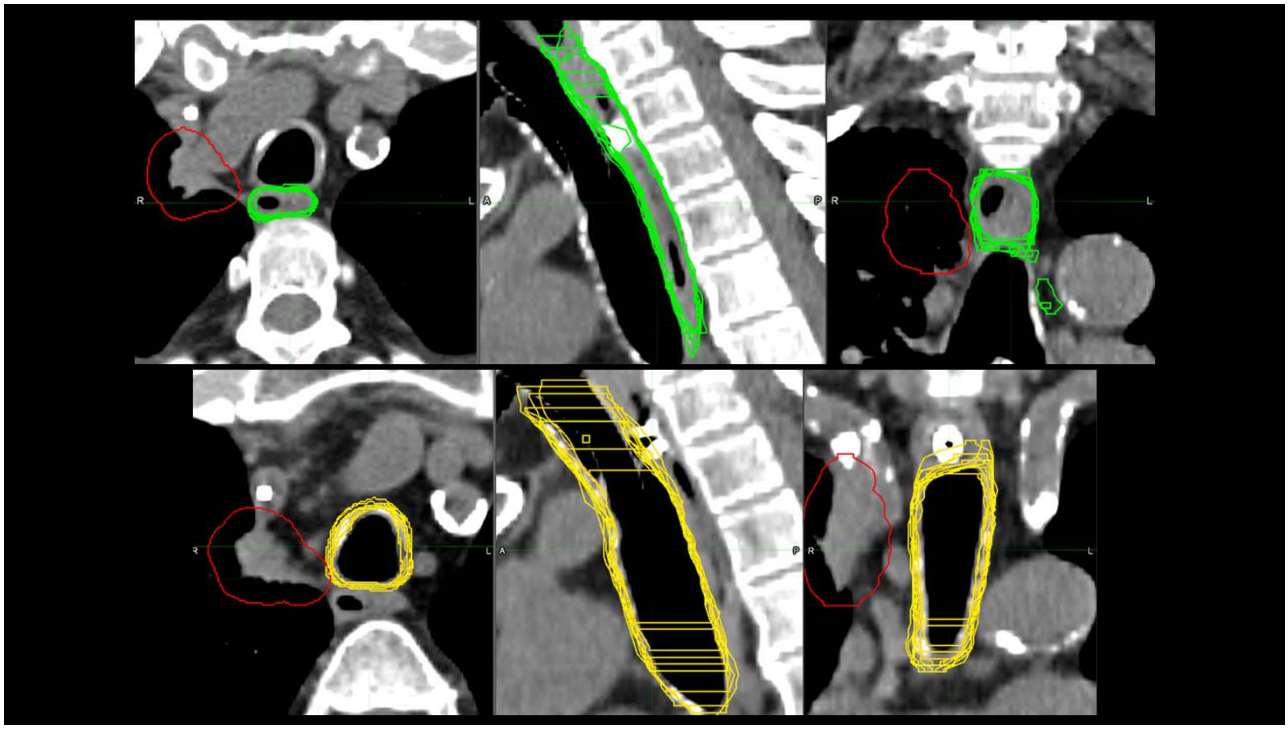
- **Assume no movement of tumor on 4DCT**

The following structures were asked to be contoured:

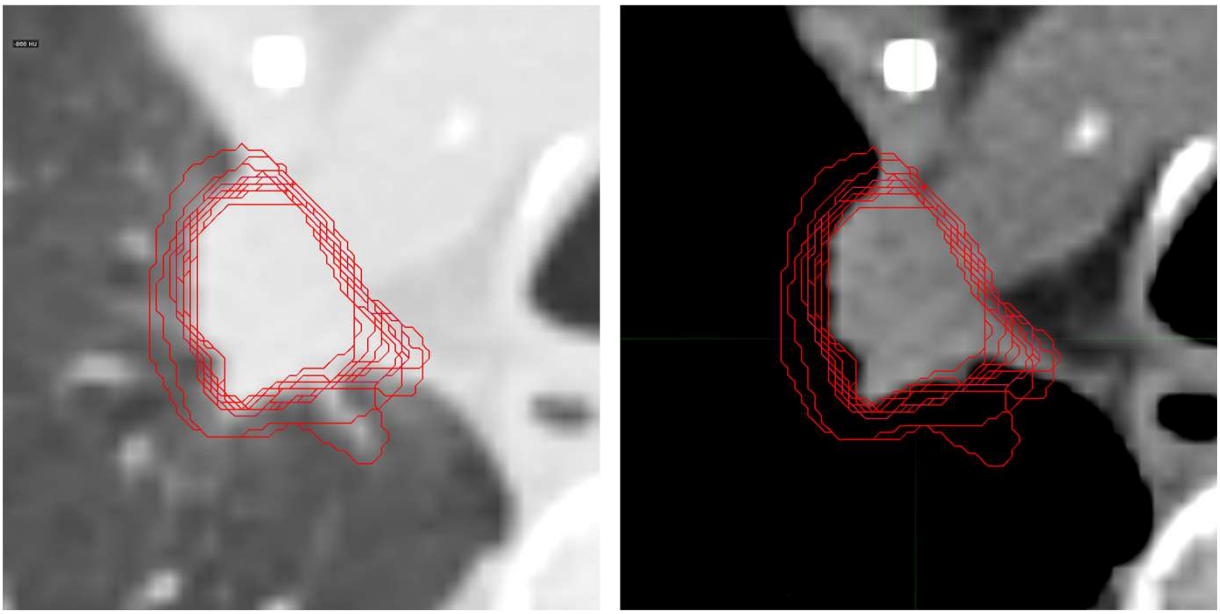
Target	OAR
GTV CTV (if needed) PTV	Spinal cord Esophagus Lungs Trachea Brachial Plexus

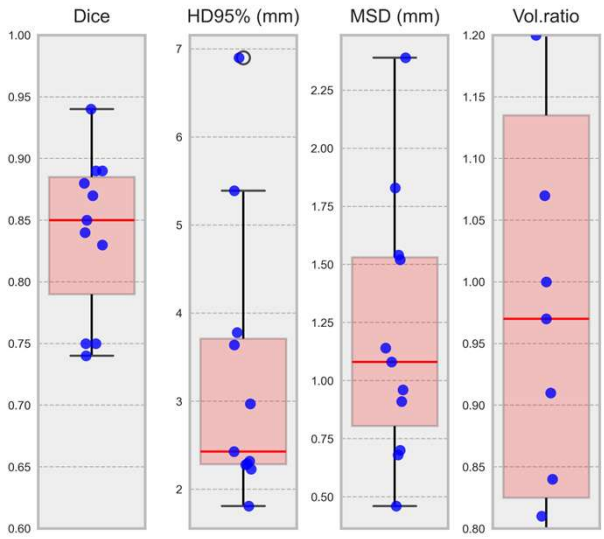



Brachialplex_R (with outlier)



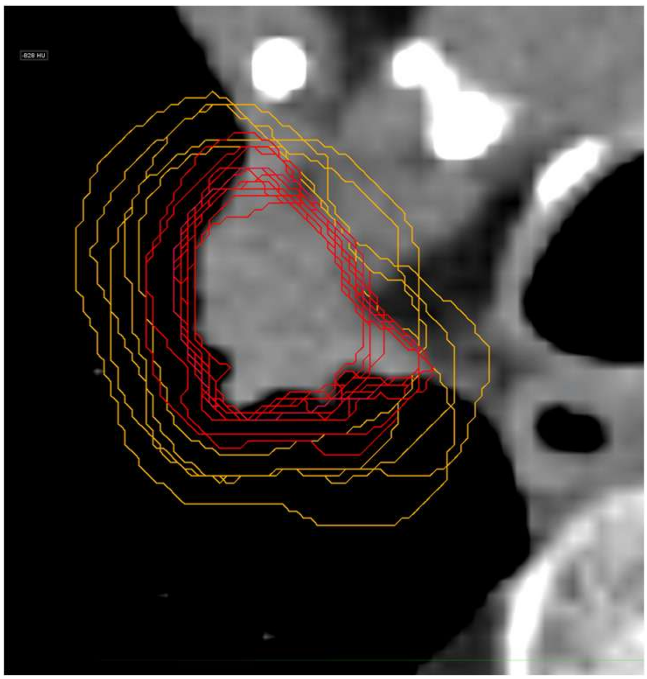
GTV

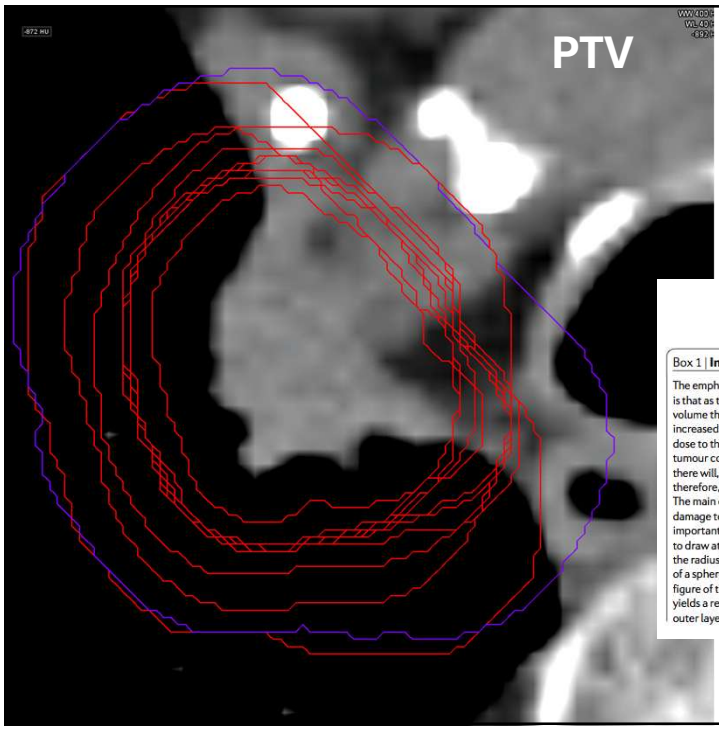



Lung SBRT
Gtv — Consensus = 6.67cm^3
Dice
HD95% (mm)
MSD (mm)
Vol.ratio
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
7
6
5
4
3
2
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80

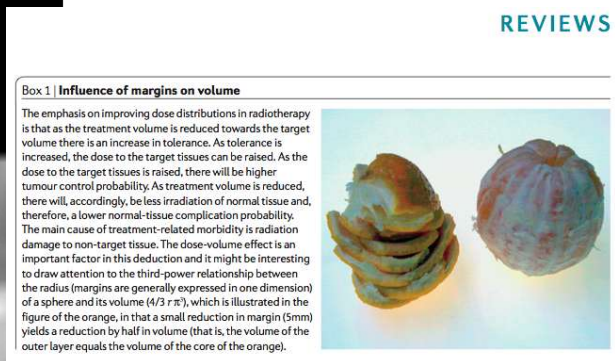
38% used a CTV

62% did not use a CTV





The largest PTV has a volume 5 times greater than that of the smallest PTV.



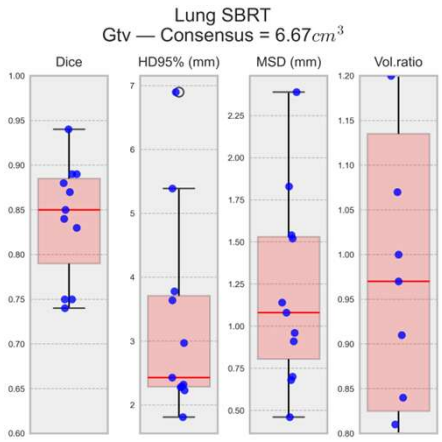
REVIEWS

Box 1 | **Influence of margins on volume**

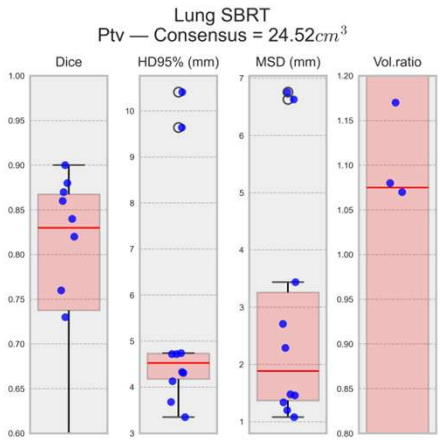
The emphasis on improving dose distributions in radiotherapy is that as the treatment volume is reduced towards the target volume there is an increase in tolerance. As tolerance is increased, the dose to the target tissues can be raised. As the dose to the target tissues is raised, there will be higher tumour control probability. As treatment volume is reduced, there will, accordingly, be less irradiation of normal tissue and, therefore, a lower normal-tissue complication probability. The main cause of treatment-related morbidity is radiation damage to non-target tissue. The dose-volume effect is an important factor in this deduction and it might be interesting to draw attention to the third-power relationship between the radius (margins are generally expressed in one dimension) of a sphere and its volume ($4/3\,\pi r^3$), which is illustrated in the figure of the orange, in that a small reduction in margin (5mm) yields a reduction by half in volume (that is, the volume of the outer layer equals the volume of the core of the orange).

Verellen et al, Nat Rev, Cancer, 2007

GTV



PTV

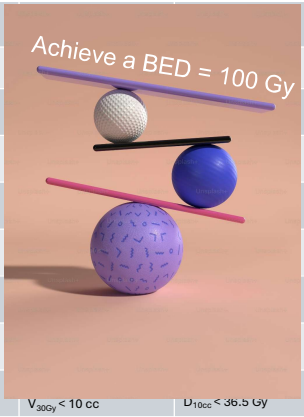


Planning questions

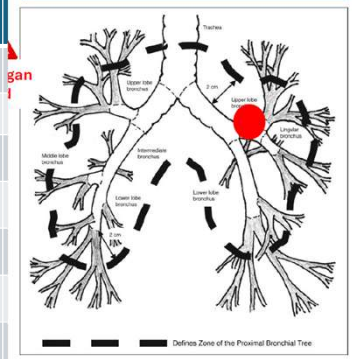
- How to balance target and OAR constraints?

Dose constraints

	3# RTOG 0618, UK 2022	4# RTOG 0915, UK 2022	5# RTOG 0813, UK 2022	8/10# UK 2022, Sunset
Spinal canal	$D_{0.035cc}$ < 20.3 Gy			$D_{0.035cc}$ < 32 Gy
Lungs - GTV	V_{20Gy} < 15% MLD < 8 Gy			V_{20Gy} < 15% MLD < 8 Gy
Trachea/PBT	$D_{0.1cc}$ < 30 Gy			$D_{0.1cc}$ < 40 Gy
Brachial plexus	$D_{0.1cc}$ < 24 Gy			$D_{0.1cc}$ < 39 Gy
Heart	$D_{0.1cc}$ < 30 Gy			$D_{0.1cc}$ < 46 Gy
Oesophagus	D_{max} < 27 Gy			D_{max} < 40 Gy
Great Vessels	$D_{0.1cc}$ < 45 Gy V_{39Gy} < 10 cc			$D_{0.1cc}$ < 65 Gy
Thoracic wall	$V_{27.3Gy}$ < 2 cc			-
Skin	$D_{0.1cc}$ < 33 Gy D_{10cc} < 30 Gy		V_{30Gy} < 10 cc	$D_{0.1cc}$ < 48 Gy D_{10cc} < 44 Gy



ULTRA-CENTRAL
Abbuting PBT, oeso, mediastin



8x7.5 Gy – 60 Gy in 10, 12 or 15#

$D_{95\%} = D_{prescribed}$

D_{max} < 120%, no endobronchial tumor

OARs constraints prioritized over PTV

RISK-ADAPTED DOSE PRESCRIPTION

Indication › Motion › Simulation › Delineation › **Planning** › IGRT › Outcome

Planning questions

- How to balance target and OAR constraints?
- **What to do with hot spots? Embrace them, avoid them or ignore them?**

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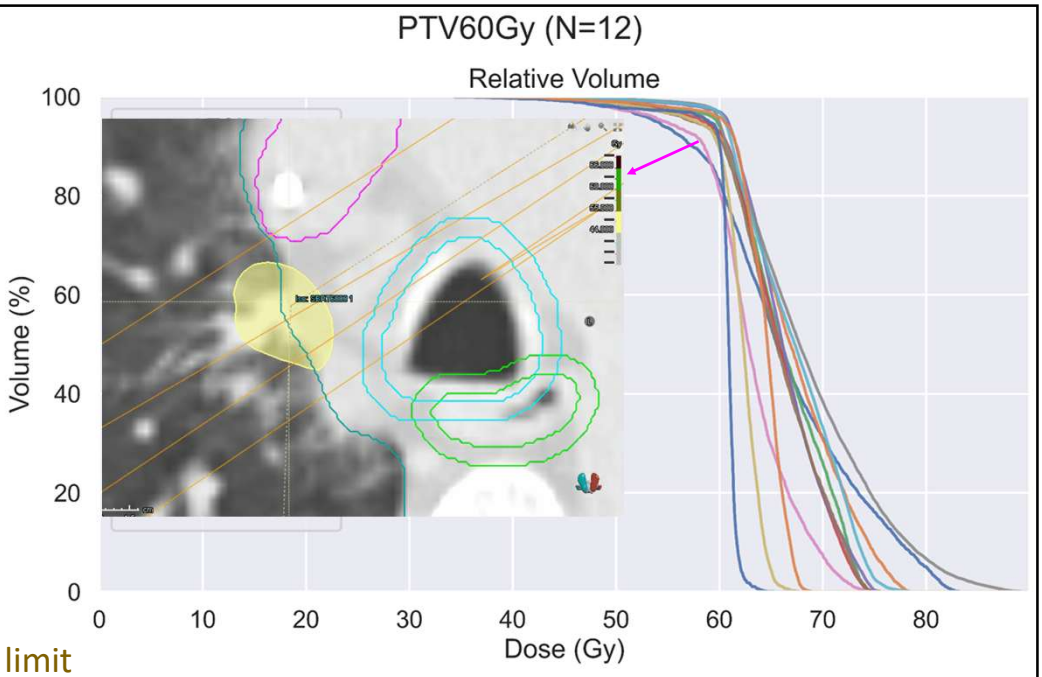
Some Like It Hot: The Value of Dose and Hot Spots in Lung Stereotactic Body Radiation Therapy

Dawn Owen, MD, PhD,* Shankar Siva, PhD, MB, FRANZCR,† Joseph K. Salama, MD,† Megan Daly, MD,§ Timothy J. Kruser, MD,‖ and Meredith Giuliani, MBBS, MEd, PhD, FRCPC¶

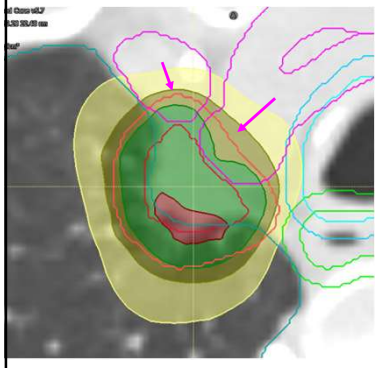
Owen, IJROBP, 2023



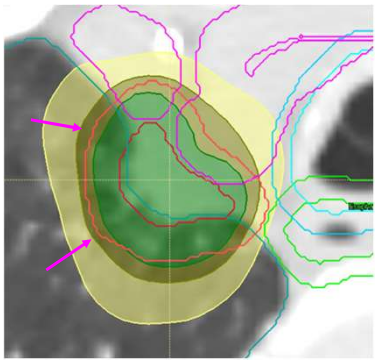
66Gy - 110%Dp
60Gy - 100%Dp
55Gy - Trachea limit
44Gy - Esophagus limit

How to improve ?

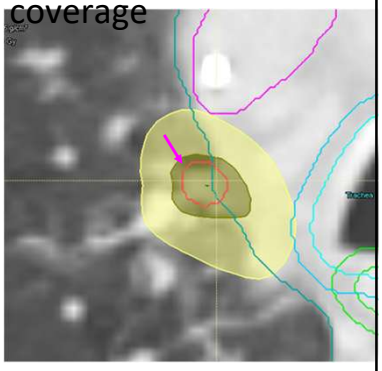
Homogeneous dose at G.V intersection



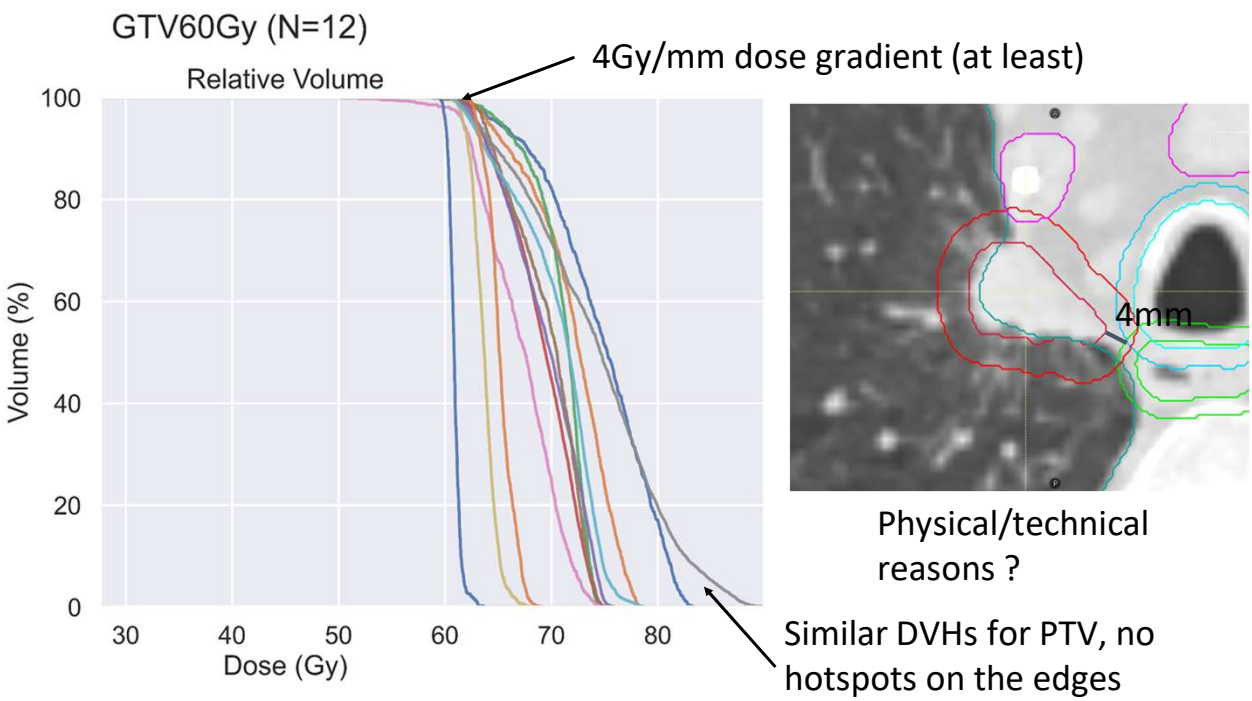
Edges coverage



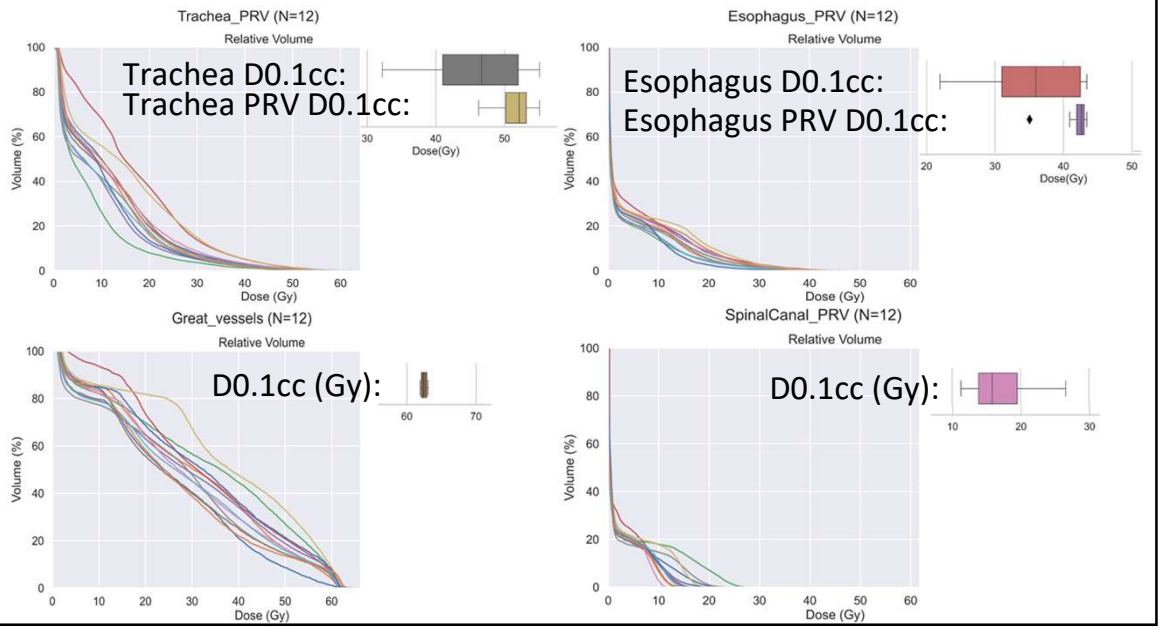
first/ last slide coverage



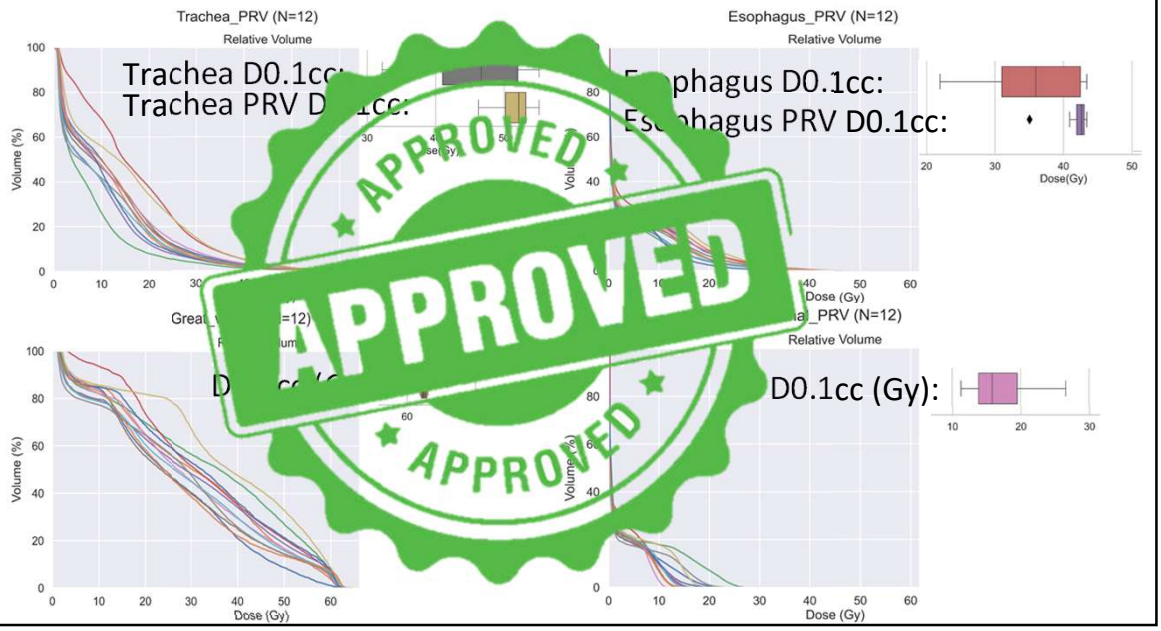
66Gy - 110%Dp 60Gy - 100%Dp 55Gy - Trachea limit 44Gy - Esophagus limit



Closest and most sensitive OARs



Closest and most sensitive OARs



Trachea D0.1cc:

Trachea PRV D 1cc:

phagus D0.1cc:

Es hagus PRV D0.1cc:

D 1cc (Gy):

D0.1cc (Gy):

Take home message

Patient would have had a safe treatment in Belgium

Goals are met ? This is not the finish line, continue

Best treatment ? You need the best machine AND the best pilote (team)