Use cases of SBRT: Liver metastases

DEGRO / DGMP AG Meeting 7.2.26

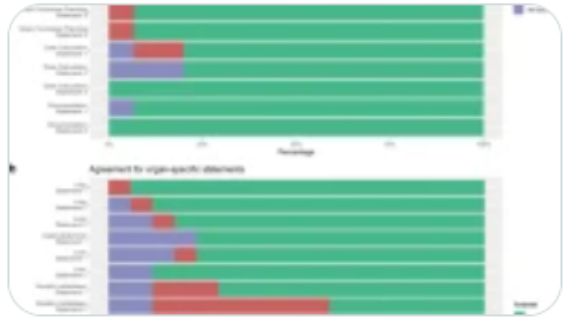
Volume 200, Issue 9

September 2024

Open access

14 articles in this issue

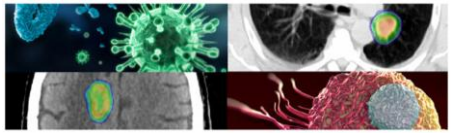
Dose prescription for stereotactic body radiotherapy: general and organ-specific consensus statement from the DEGRO/DGMP Working Group Stereotactic Radiotherapy and Radiosurgery



Thomas B. Brunner, Judit Boda-Heggemann ... Oliver Blanck

Review Article | Open access | 12 July 2024 | Pages: 737 - 750

Purpose/Objectives:



- Develop expert recommendations for multiparametric dose prescriptions of SBRT according to ICRU report 91!

- Harmonize current SBRT practice and for trial design!

- Refine dose prescription and documentation requirements!

Materials and Methods

4. Delphi 2nd round

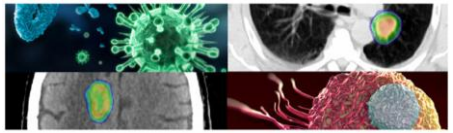
1. Literature review

3. live discussion

5. Result

2. Delphi 1st round

Overarching Statements



Topic	Question	Agreement (%)
Dose prescription	… should be **prescribed to a PTV encompassing isodose** (e.g., PTV D95-98%) … reported based on ICRU report 91	100
	… must be accompanied **by further dosimetric goals** to be achieved in the GTV	100
	.. dose prescription to the **GTV median dose** could be considered if further goals for the PTV	100
	LQ model to convert different SBRT dose prescription schemes from A to B fractions.	86
Beam Technique Planning	including **SIP and SIB concepts** … to achieve optimal trade-offs between TV dose coverage and OAR sparing	100
	robust SBRT plans: **reduction of interplay effects**	94

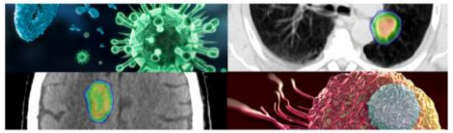
Overarching Statements

Topic	Question	Agreement (%)
Dose Calculation	**Density override** … of artifacts in or near the PTV	88
	large density inhomogeneities: **algorithm for lateral electron transport**	100
	maximum **grid size 1–2 mm**	100
Documentation	**document** dosimetric plan information and **report** a/to ICRU 91 with **at minimum** •the PTV prescription dose •PTV D98% •PTV D50% •PTV D_near-max (D2% or D_0.035 mL) •GTV D50% and GTV $D_{near\text{-}max}$ •if applicable ITV D50% and ITV $D_{near\text{-}max}$ •all OARs: Dnear_max and D_mean	100
	motion management strategy: report a/to ICRU 91	100

Organ specific statements

Topic	Question	Agreement (%)
Lung	For peripheral tumors dose should be escalated to the GTV/ITV while ensuring a reasonable dose to the PTV.	94
	For ultracentral tumors, dose sparing of bronchial tree, trachea and esophagus based on clinically accepted dose limitations must have priority over PTV coverage. (*1)	94
	Dose prescription of primary lung tumors should not be different than for pulmonary metastases if ablation is intended. [Guckenberger M, et al. Radiother Oncol. 2016 Mar;118(3):485-91. doi: 10.1016/j.radonc.2015.09.008] (*2)	93
Upper abdomen	Dose prescription to upper abdominal target volumes that are close to stomach and / or duodenum should imply the administration of prophylactic gastric acid reduction with proton pump inhibitors. (*4)	100
Liver in general	Dose prescription to PTV areas containing patent, i.e. non-tumor affected / non-obstructed central bile ducts, specifically the common bile duct and the common hepatic duct, should avoid dose escalation in these areas. [Timmerman R. Int J Radiat Oncol Biol Phys. 2022 Jan 1;112(1):4-21. doi: 10.1016/j.ijrobp.2021.09.027; Diez P, et al. Clin Oncol. 2022 May;34(5):288-300. doi: 10.1016/j.clon.2022.02.010; Toesca DA, et al. Radiother Oncol. 2017 Jan;122(1):130-136. doi: 10.1016/j.radonc.2016.10.024] (*3)	93
	Liver function must be taken into account for dose prescription especially in HCC (protected liver volume, Child-Pugh score, ALBI score, etc.) to avoid the risk of radiation induced liver disease. (*2)	100
Hepatic metastases	Liver metastases from colorectal cancer should be treated with higher prescription dose compared to liver metastases from other primary tumors to achieve similar local control. [Klement RJ, et al. Radiother Oncol. 2017 May;123(2):227-233. doi: 10.1016/j.radonc.2017.01.013] (*2)	80
	Liver metastases should be treated with higher prescription doses after chemotherapy compared to chemotherapy-naive liver metastases. [Klement RJ, et al. Radiother Oncol. 2017 May;123(2):227-233. doi: 10.1016/j.radonc.2017.01.013] (*2)	47
Hepatocellular carcinoma	Since a clinically accepted dose-response relationship (tumor control probability; TCP) is not known, dose prescription should be adapted to liver function to reduce the risk of radiation 100induced liver disease. (*3)	93
	Dose prescription in patients with Child-Pugh scores >8 should maximize sparing of non-tumor liver volume including reduction of the prescribed dose to target volumes in an individualized approach. [Culleton S, et al. Radiother Oncol. 2014 Jun;111(3):412-7. doi: 10.1016/j.radonc.2014.05.002] (*4)	100
Cholangio-carcinoma	Dose prescription for primary intrahepatic and perihilar cholangiocarcinoma should not be different than for liver metastases. (*5)	92
Pancreatic ductal adeno-carcinoma	Pancreatic lesions should be treated with 5 or more fractions outside of prospective clinical trials. (*1)	100
	For pancreatic lesions, dose sparing of hollow OAR based on clinically accepted dose limitations must have priority over PTV coverage. (*1)	88
Renal cell cancer	Renal cell cancer should be treated with single fraction SBRT due to radiobiological characteristics of the tumors. [Siva S, et al. Lancet Oncol. 2022 Dec;23(12):1508-1516. doi: 10.1016/S1470-2045(22)00656-8; Mizowaki T. Lancet Oncol. 2022 Dec;23(12):1476-1477. doi: 10.1016/S1470-2045(22)00697-0.] (*1)	13
	Dose prescription should be based on the results of a split renal function to determine the relative contribution of each of the two kidneys to total renal function, e.g., with renal scintigraphy. (*2)	100
Adrenal metastases	Dose prescription for both, bilateral and unilateral adrenal SBRT, should mandate hormone and /or endocrinological monitoring in the planning process. [Buergy et al. 2021; Brauckhoff M. et al. 2003] (*4)	85
	Dose prescription should prioritize tolerance doses of neighbouring organs at risk (e.g. stomach, duodenum, small bowel) over PTV coverage. (*1)	94

Organ specific statements:
Primary Liver

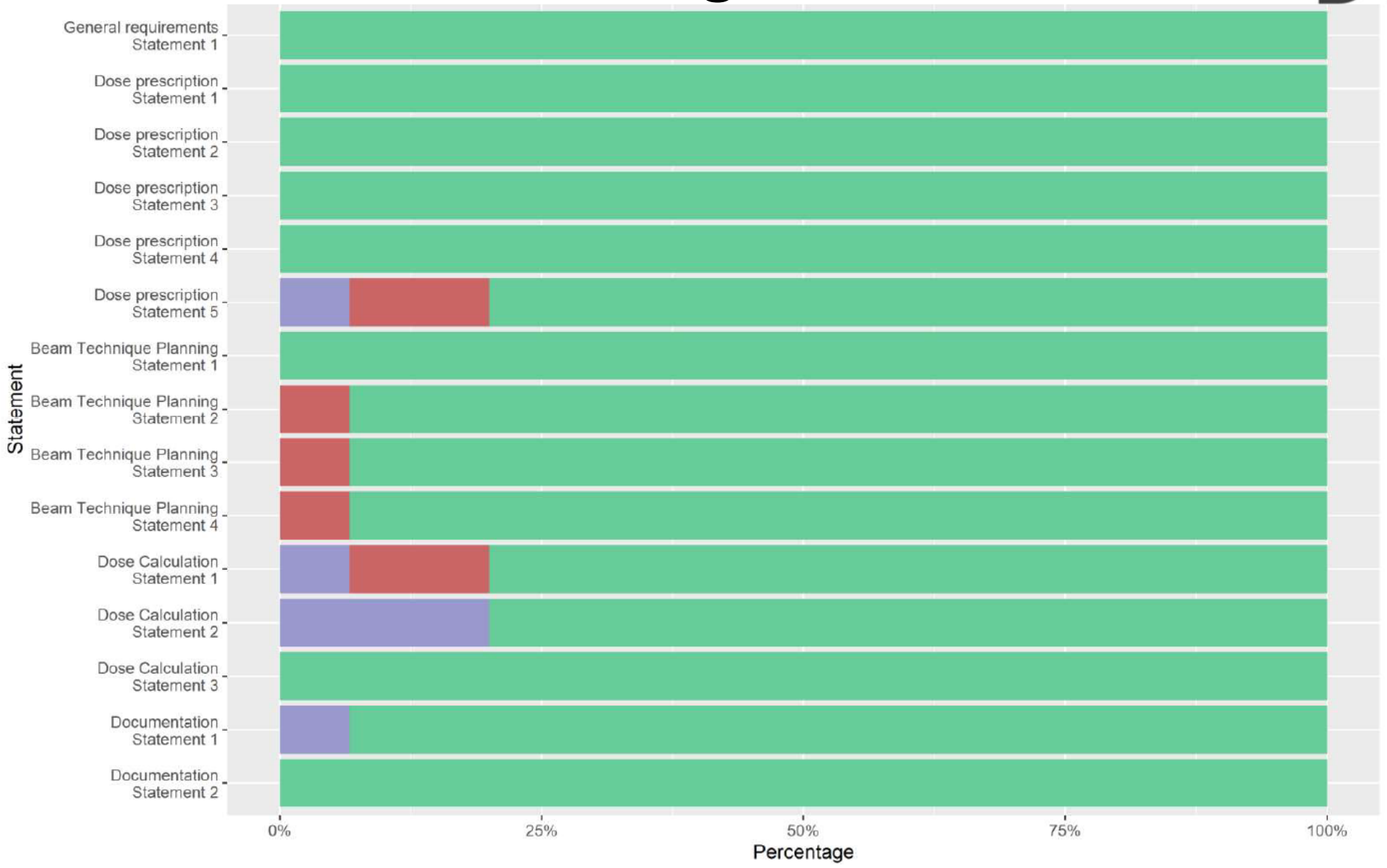


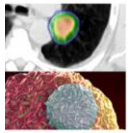
Topic	Question	Agree (%)
Upper abdomen	Dose prescription **close to stomach a/o duodenum** should imply the administration of **prophylactic gastric acid reduction** with proton pump inhibitors.	100
Liver in general	PTV areas containing patent, i.e. non-tumor affected / non-obstructed **central bile ducts**, i.e. CBD and the CHD: **avoid dose escalation**! [Timmerman R. IJROBP 2022; Diez P, et al. Clin Oncol. 2022; Toesca DA, et al. Radiother Oncol. 2017] (*3)	93
	Liver function must be taken into account for dose prescription especially in HCC (protected liver volume, Child-Pugh score, ALBI score, etc.) to avoid the risk of radiation induced liver disease	100
Hepatic metastases	Liver **metastases from colorectal cancer should be treated with higher prescription dose** compared to liver metastases from other primary tumors to achieve similar local control. [Klement RJ, et al. Radiother Oncol. 2017] (*2)	80
	Liver metastases should be treated with higher prescription doses **after chemotherapy** compared to chemotherapy-naive liver metastases. [Klement RJ, et al. Radiother Oncol.] (*2)	**47**

Results: Delphi Round 2

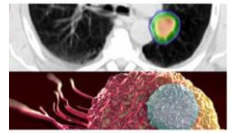
- ***Degree of consent ≥80%:***
- 100% for overarching statements
- 88% for organ specific statements

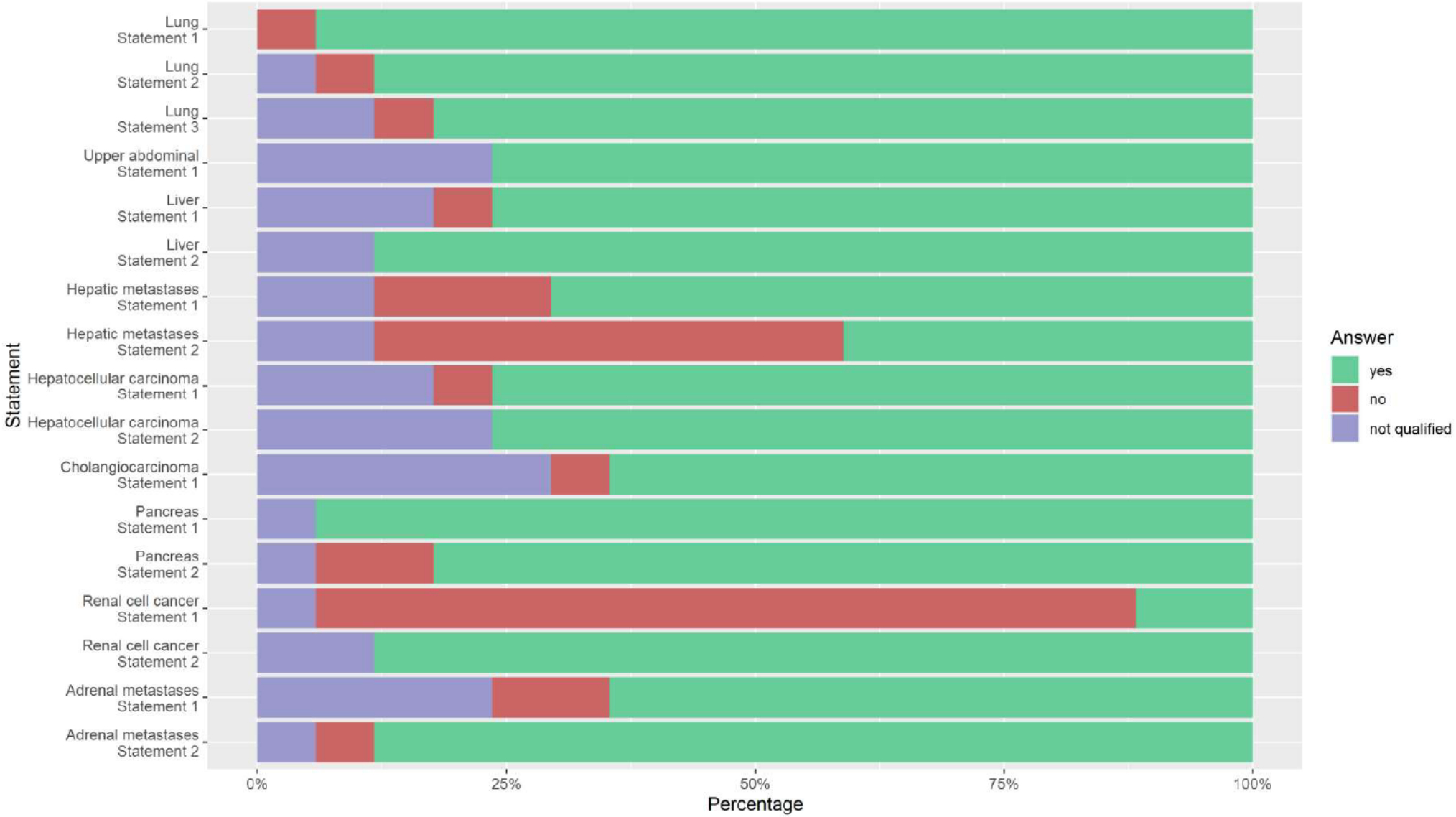
Overarching Statements



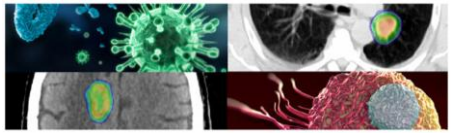


Organ Specific Statements





Results: Delphi Round 2

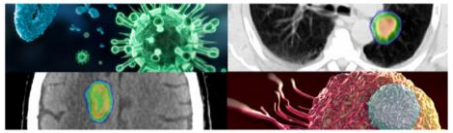


No consensus ≥80% for:

1. Dose escalation of liver metastases after chemotherapy (47%)
2. Single fraction SBRT for kidney primaries (13%)

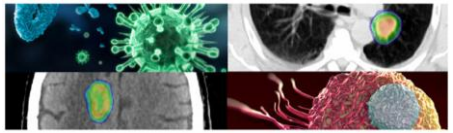
In round 2, no statements had 60-79% consensus.

Organ specific statements



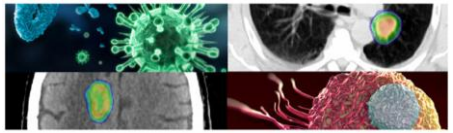
Topic	Question	Agreement (%)
Hepatic metastases	Treat M_{hep} from colorectal cancer with higher prescription dose compared to non-CRC to achieve similar local control. [Klement RJ, et al. Radiother Oncol. 2017] (*2)	80
	Treat M_{hep} post chemo with higher prescription doses compared to chemo-naive [Klement RJ, et al. Radiother Oncol. 2017] (*2)	47
Renal cell cancer	Treat RCC with single fraction SBRT due to radiobiological characteristics of the tumors. [Siva S, et al. Lancet Oncol. 2022; Mizowaki T. Lancet Oncol. 2022] (*1)	13

Conclusion



1. 94% high consensus in the Delphi (31 statements)
2. Clear recommendations for overarching and organ specific topics could be defined
3. Significant harmonization for daily practice and for the design of clinical trials in SBRT
4. **Next step: Specific exemplary cases are prepared**

Material & Methods – General standards



1. Indication
2. Planning CT scan (pat. Position; abdominal compression; motion management; i.v./oral contrast; 4D-CT imaging; …
3. Image fusion; contouring; dose prescription
4. Planning; plan approval
5. Treatment; PPI; fasting; oral contrast; IGRT
6. Follow-up

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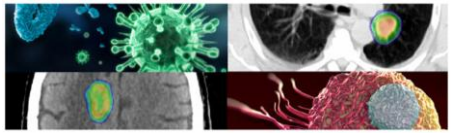
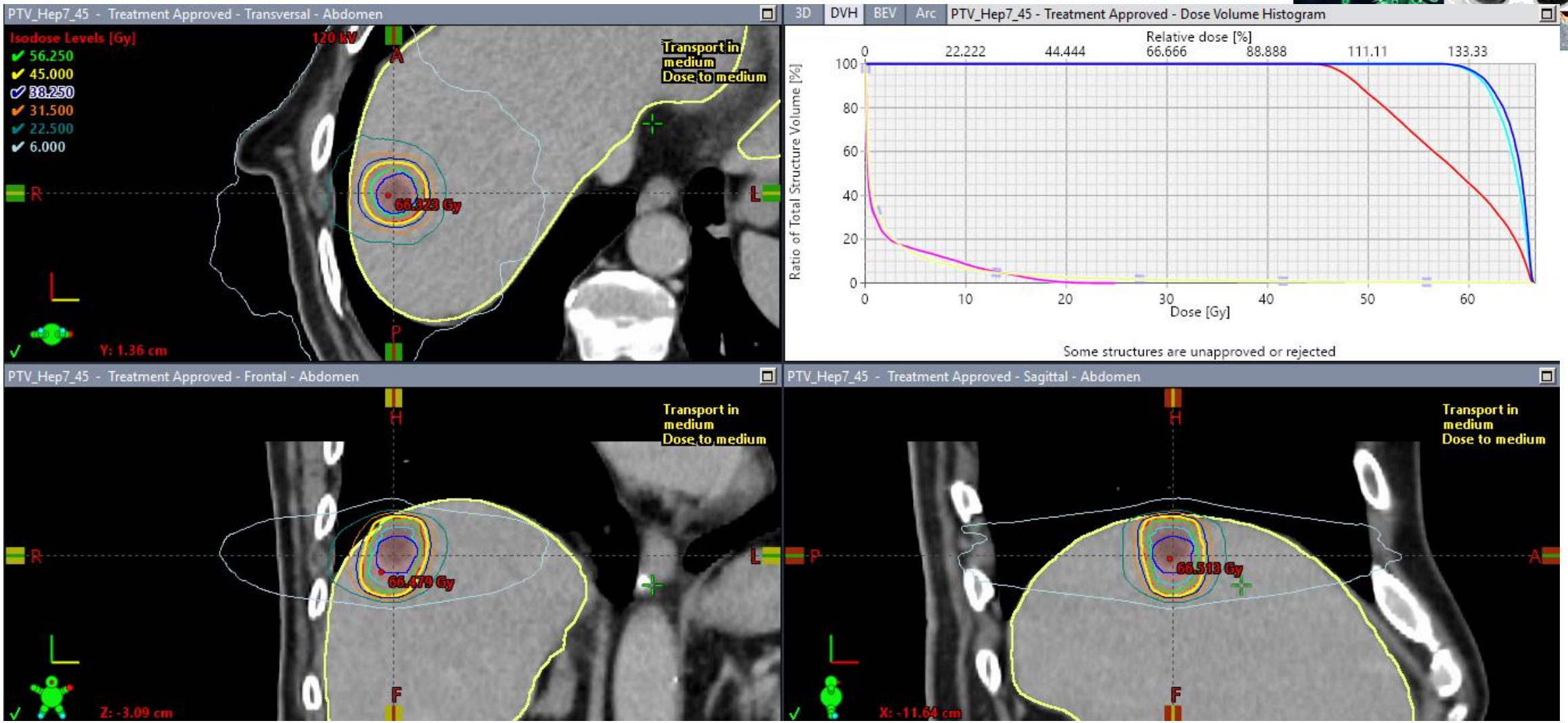
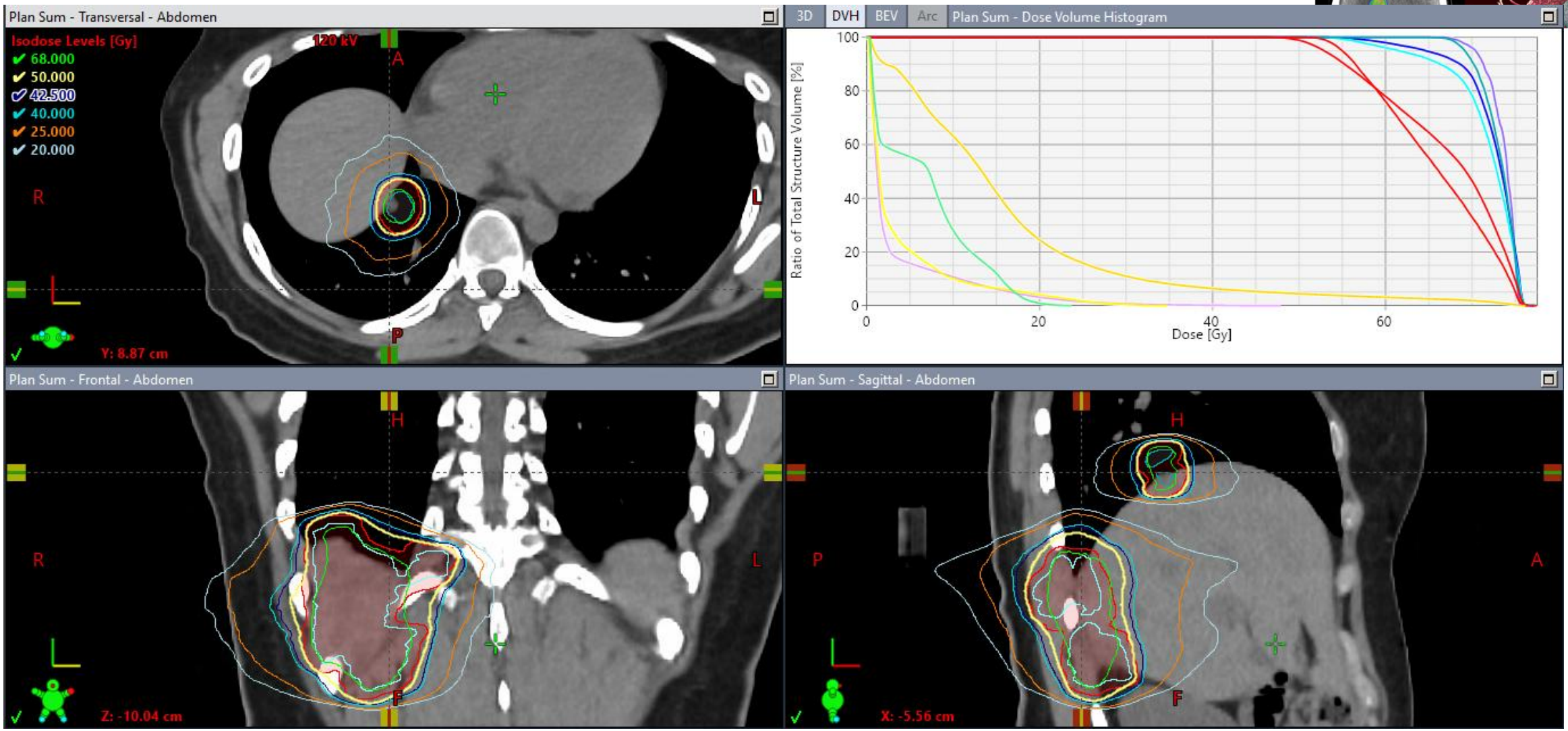


Parameters	Case 1	Case 2	Case 3		Case 4
Primary tumour	Head and neck squamous cell carcinoma	Ewing sarcoma	Colorectal cancer		CUP – undifferentiated spindle cell carcinoma
Liver segments	S. 8	S. 6-7/7	S. 8	S. 4a, 4b, 5	S. 6, 7
volume (cc)	3.1 cc	39.9; 1.0 cc	3.1 cc	1.4; 0.7; 16.1 cc	852.7 cc
Isocenter(s)	1	2	Iso. 1	Iso. 2	1

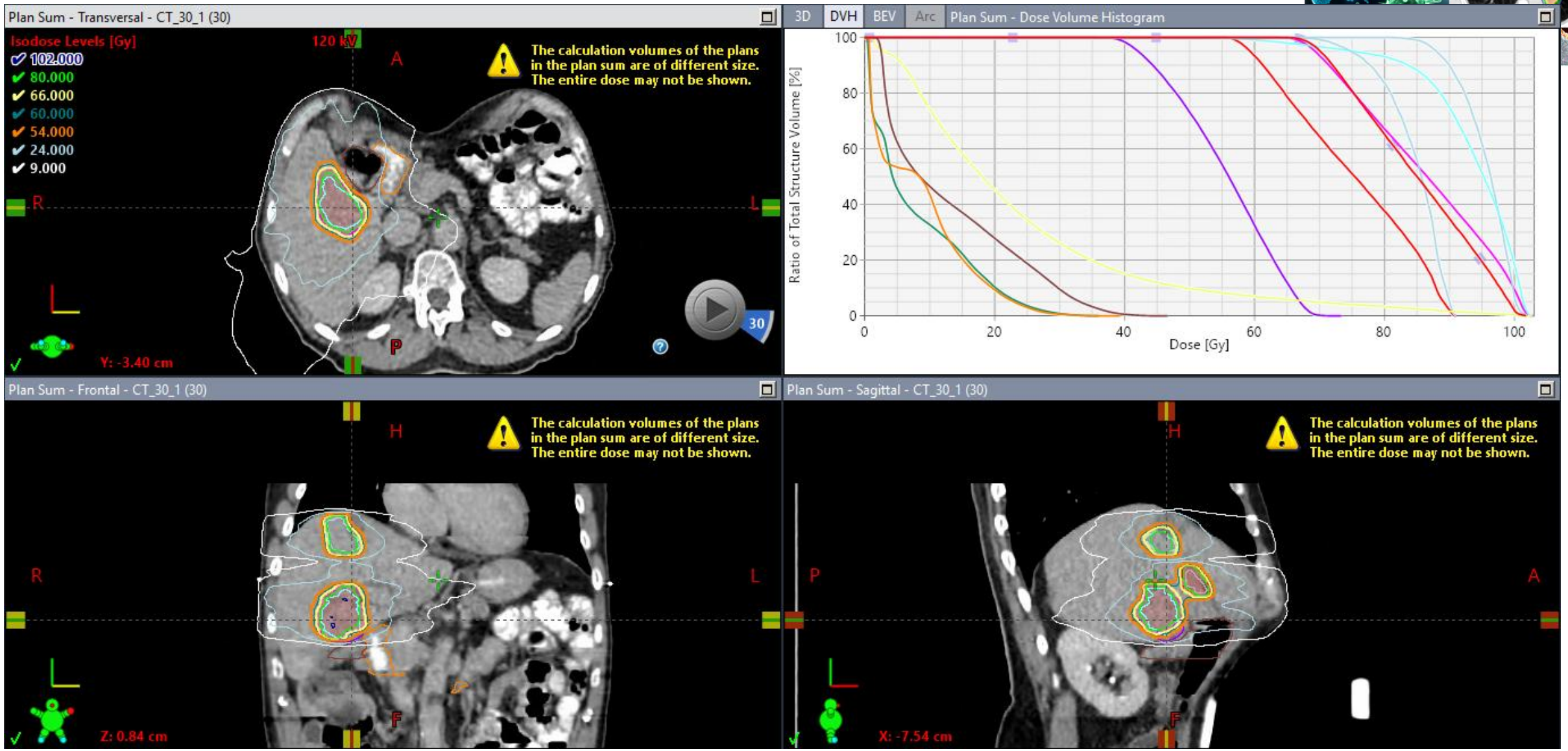
Case 1: HNSCC - synchronous de novo



Case 2: Ewing - induced om



Case 3: Colorectal - induced om



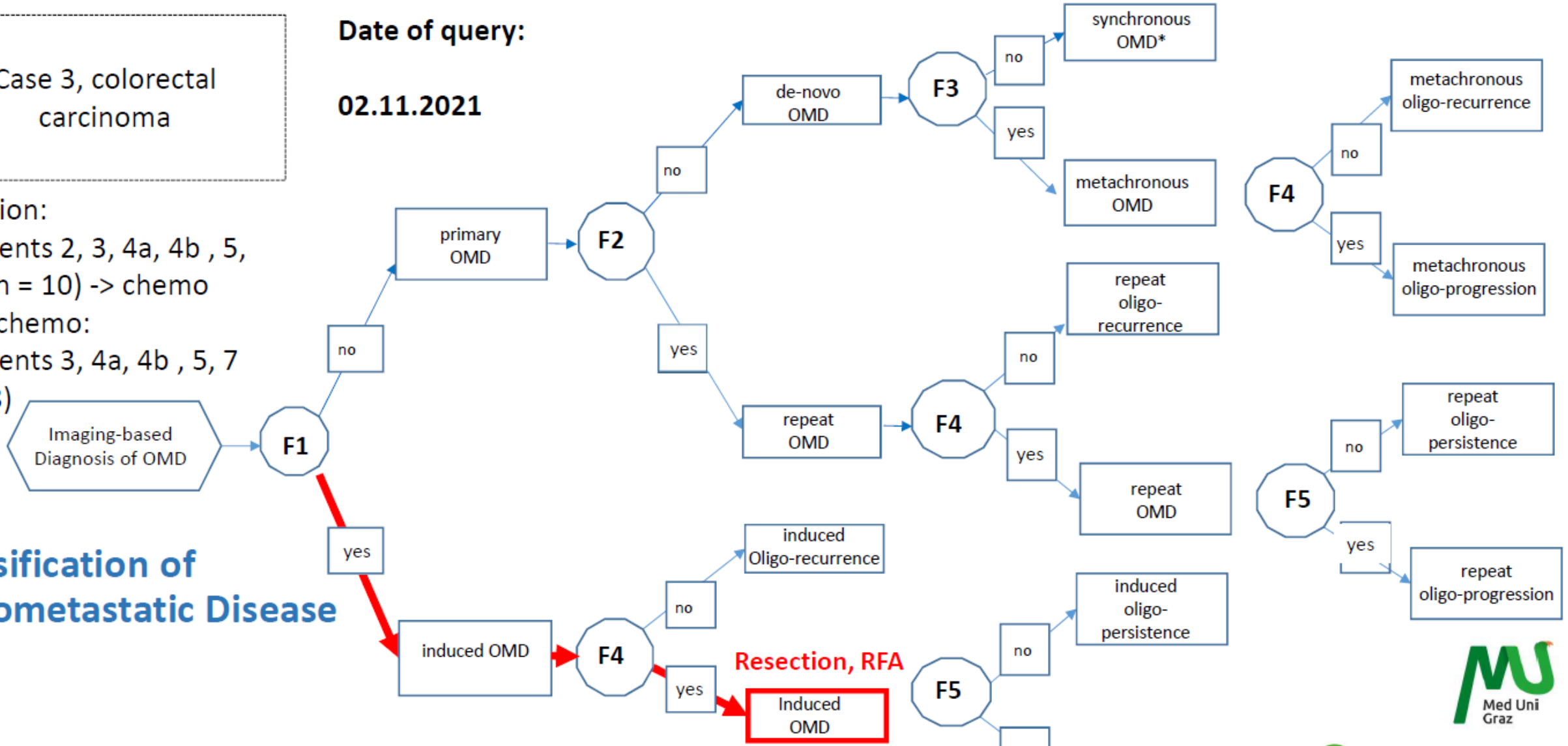
Case 3, colorectal carcinoma

Date of query:

02.11.2021

Location:
segments 2, 3, 4a, 4b , 5, 7, 8 (n = 10) -> chemo
Post-chemo:
segments 3, 4a, 4b , 5, 7 (n = 8)

Classification of Oligometastatic Disease



Decision tree for the classification of oligometastatic disease (OMD)

Question 1: Does the patient have a history of polymetastatic disease prior to the current diagnosis of OMD?
Question 2: Does the patient have a history of OMD prior to the current diagnosis of OMD?
Question 3: Was the OMD first diagnosed > 6 months after the primary diagnosis of the tumor?
Question 4: Is the patient under active systemic therapy at the time of diagnosis of OMD?
Question 5: Are any oligometastatic lesions progressive in the current imaging?

University Clinic for Radiation Therapy-Radiooncology, Prof. Dr. T. Brunner

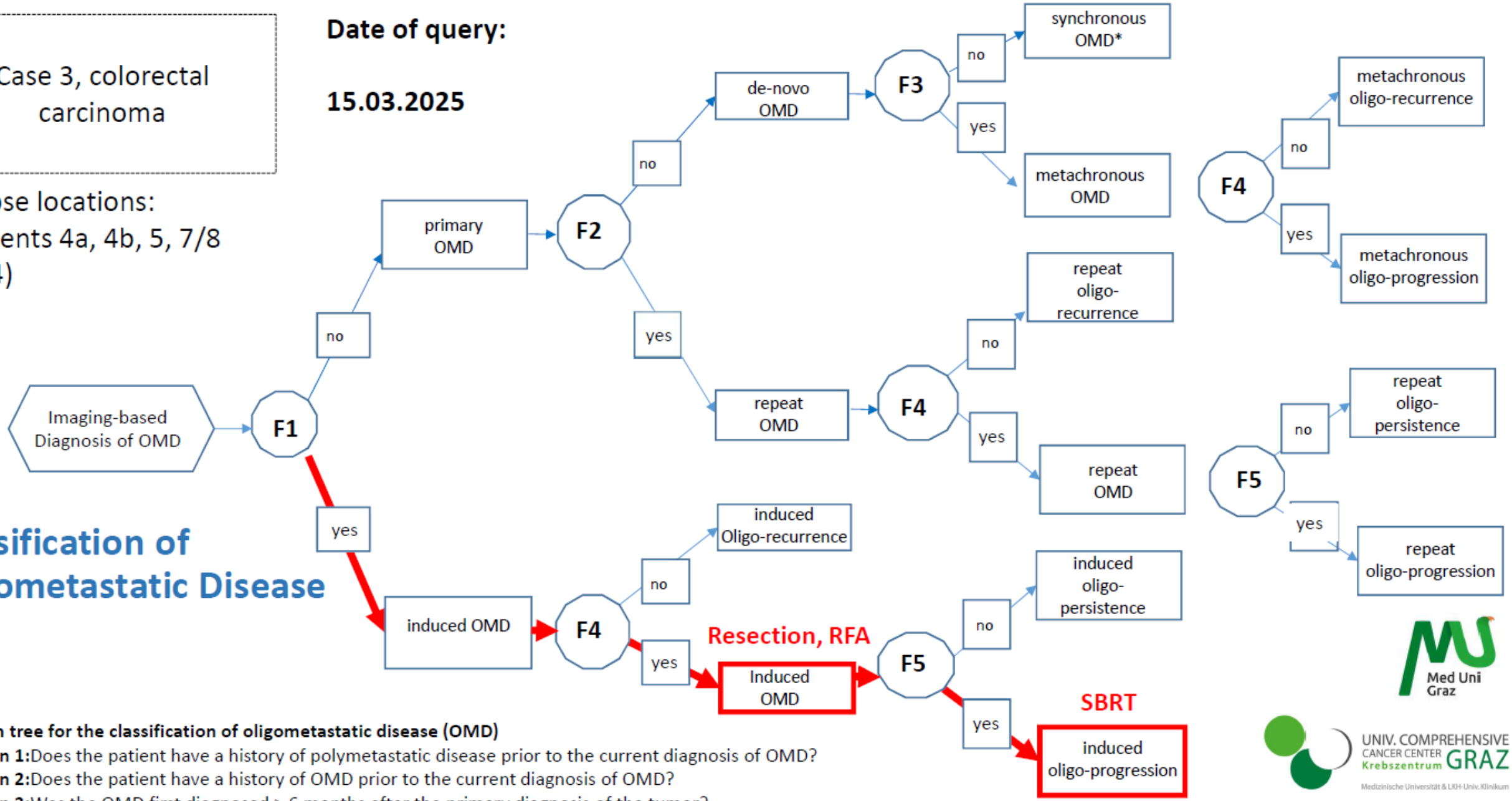
Quelle: Lancet Oncol. 2020 Jan;21(1):e18-e28. doi: 10.1016/S1470-2045(19)30718-1. Characterisation and classification of oligometastatic disease: an ESTRO and EORTC consensus recommendation. Guckenberger et al.

Case 3, colorectal carcinoma

Date of query:

15.03.2025

Relapse locations:
segments 4a, 4b, 5, 7/8
(n = 4)



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UNIV. COMPREHENSIVE CANCER CENTER Krebszentrum GRAZ
Medizinische Universität & LKH-Univ. Klinikum

University Clinic for Radiation Therapy-Radiooncology, Prof. Dr. T. Brunner

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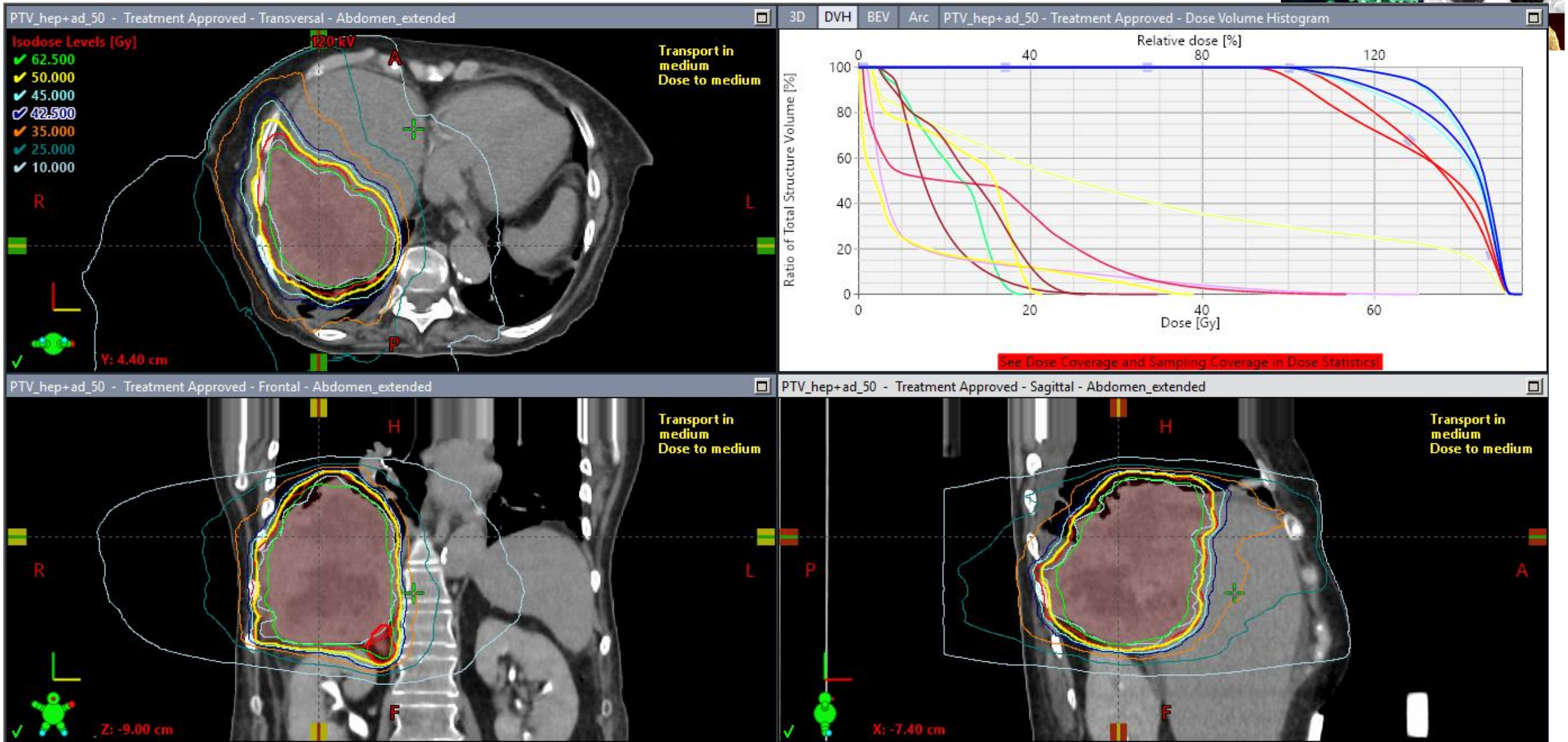
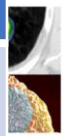
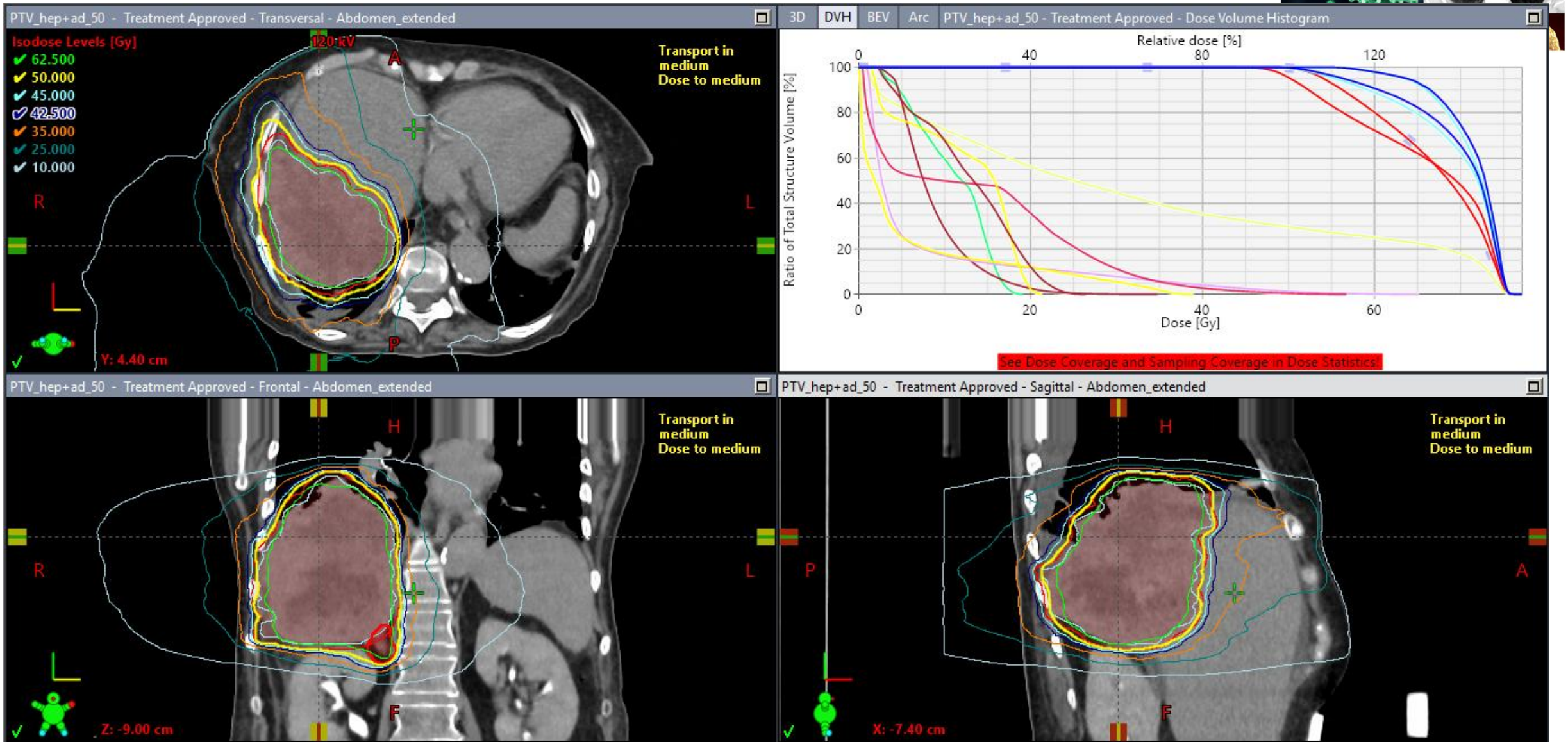
Case 4: CUP - de novo



Parameters	Case 1	Case 2	Case 3		Case 4
Primary tumour	Head and neck squamous cell carcinoma	Ewing sarcoma	Colorectal cancer		CUP – undifferentiated spindle cell carcinoma
Adjacent critical OARs	none	Chest wall	none	Colon, duodenum, bile duct	Chest wall, lower lobe bronchus
Prescription isodose	65%	65%	60%	60%	65%
Number of fractions	3	5	3	12	5
SIP	n.a.	n.a.	n.a.	PTV_dom / PTV_SIP	n.a.



Case 4: CUP - de novo



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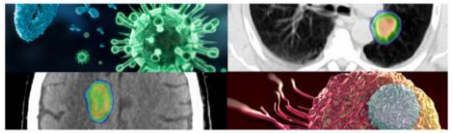
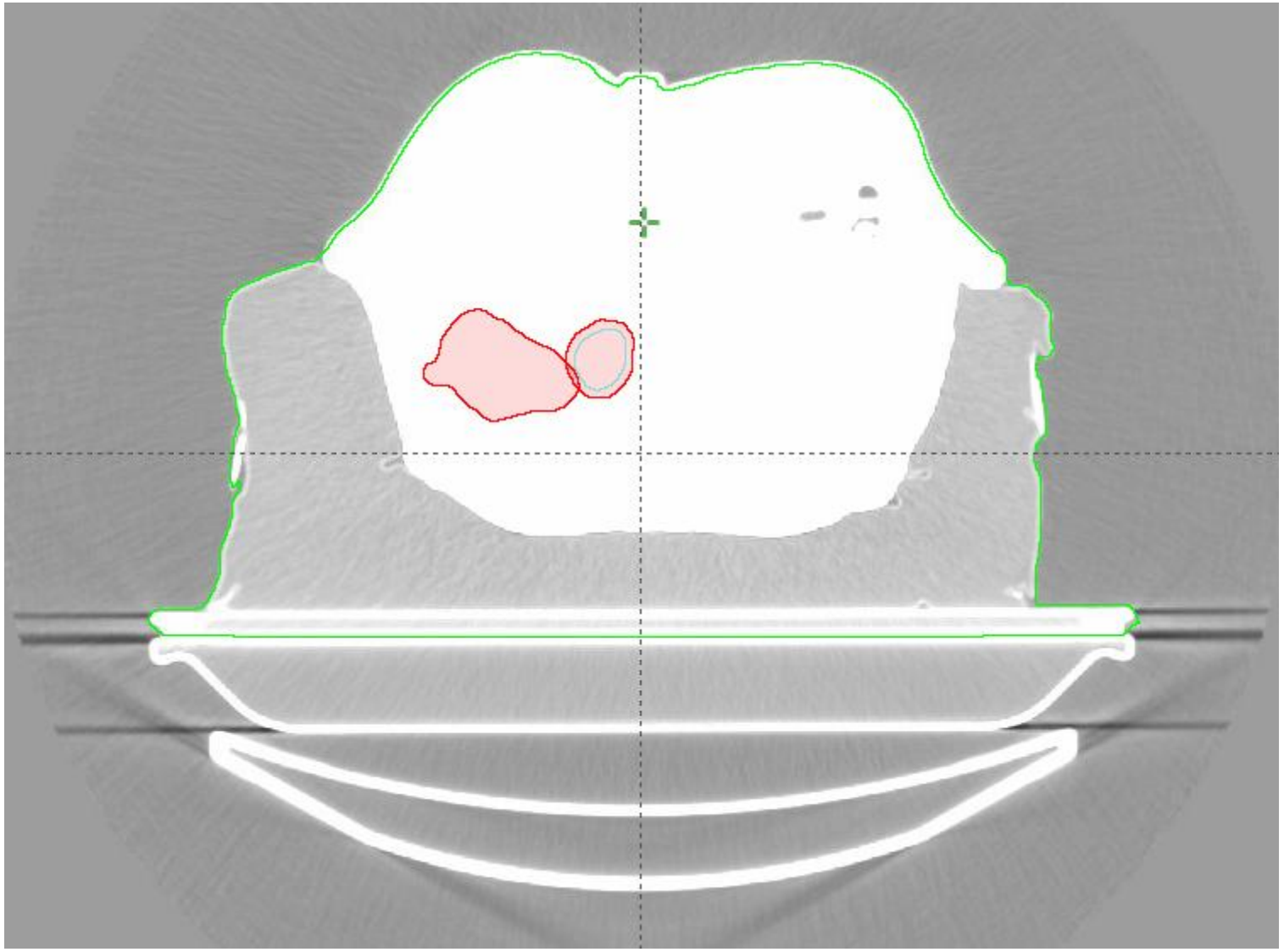


Suppl. Fig.: Patient positioning



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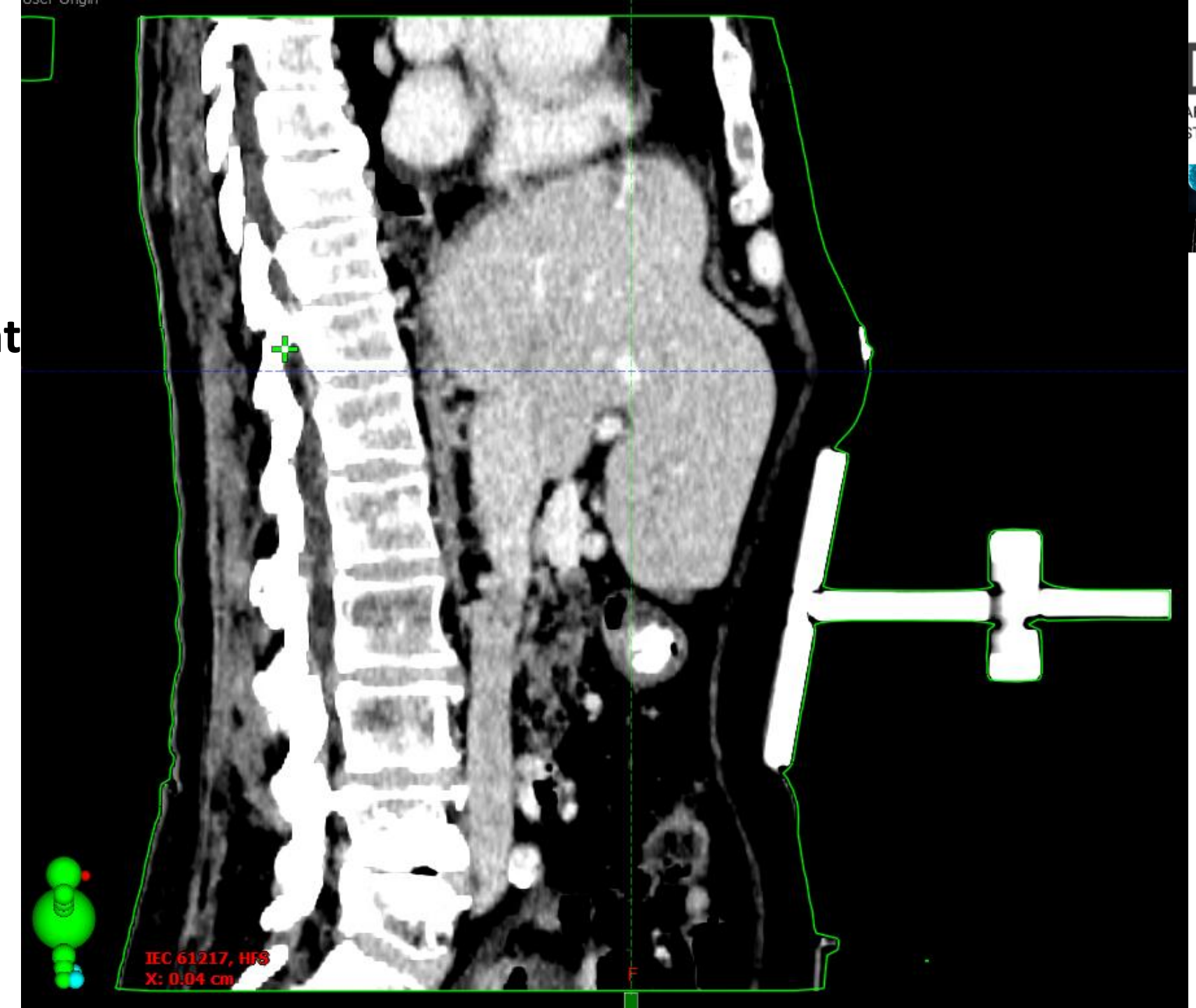
STEREOTAXIE

Suppl. Fig.: Motion Management



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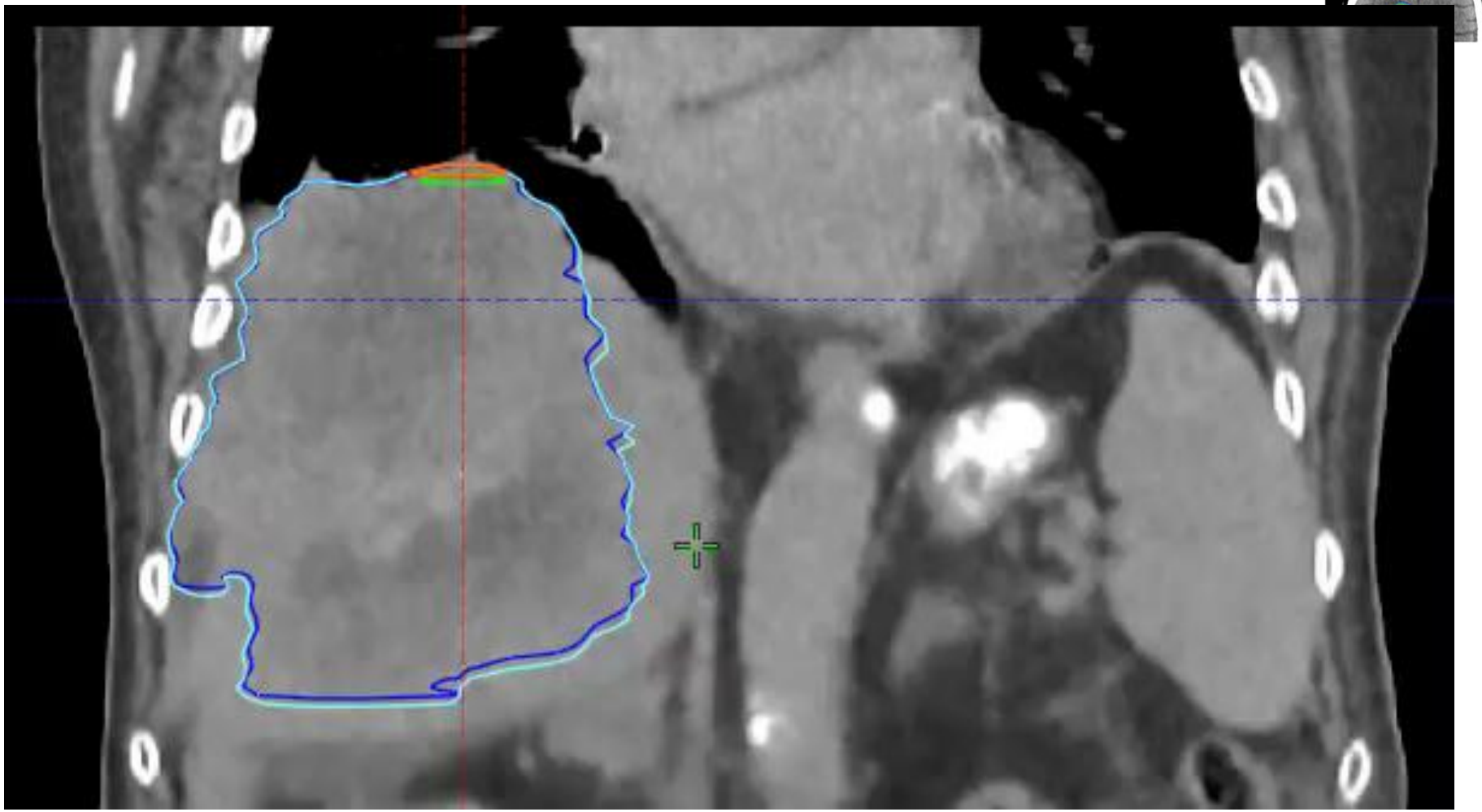
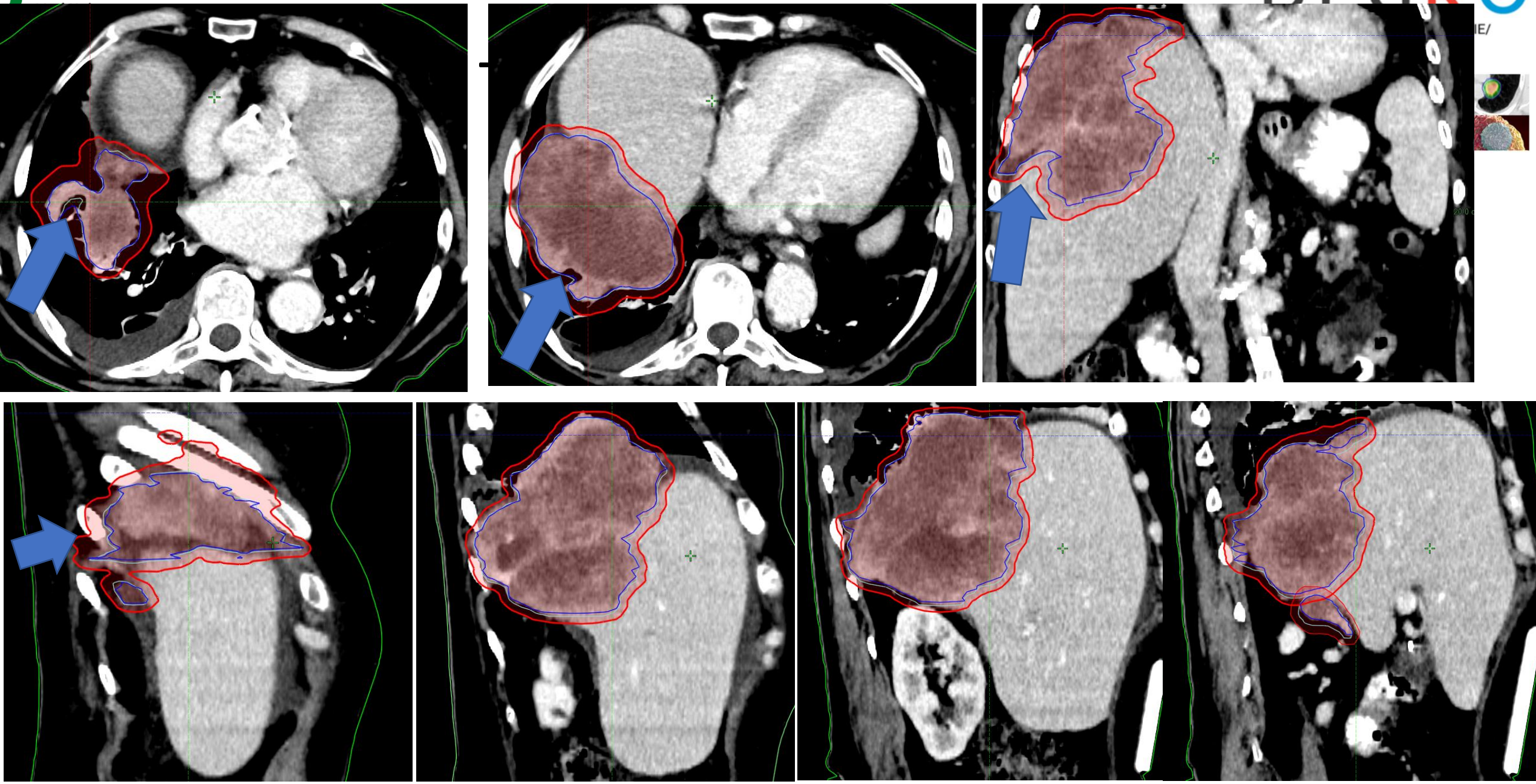
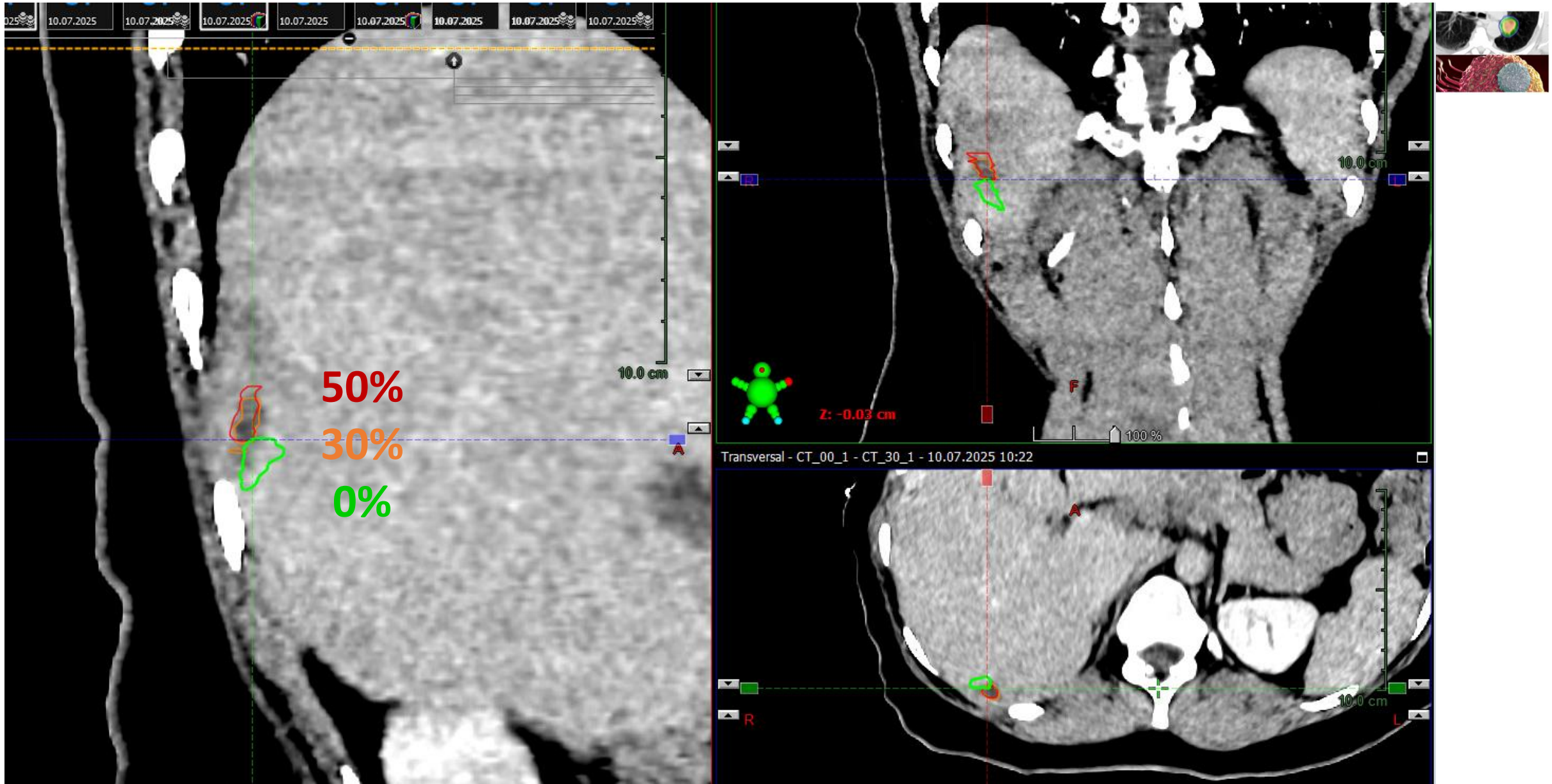
Suppl. Fig.: Motion Management



Suppl. Fig. 4c: Contouring

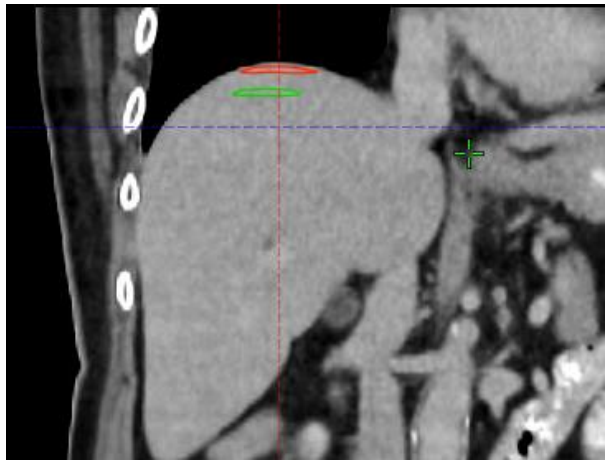


Suppl. Fig.: IGRT in Case 2 – Traffic light system



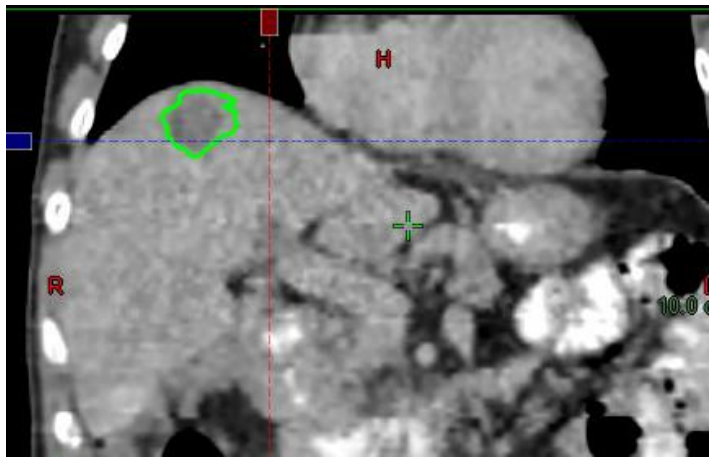
Suppl. Fig.: IGRT – define personalized @ contouring

Case 1

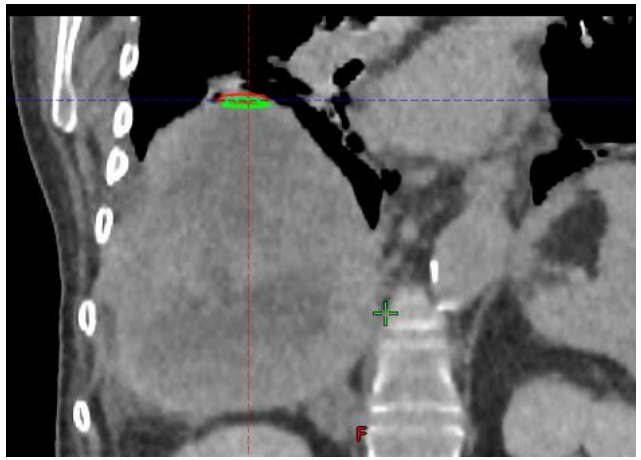


Case 2

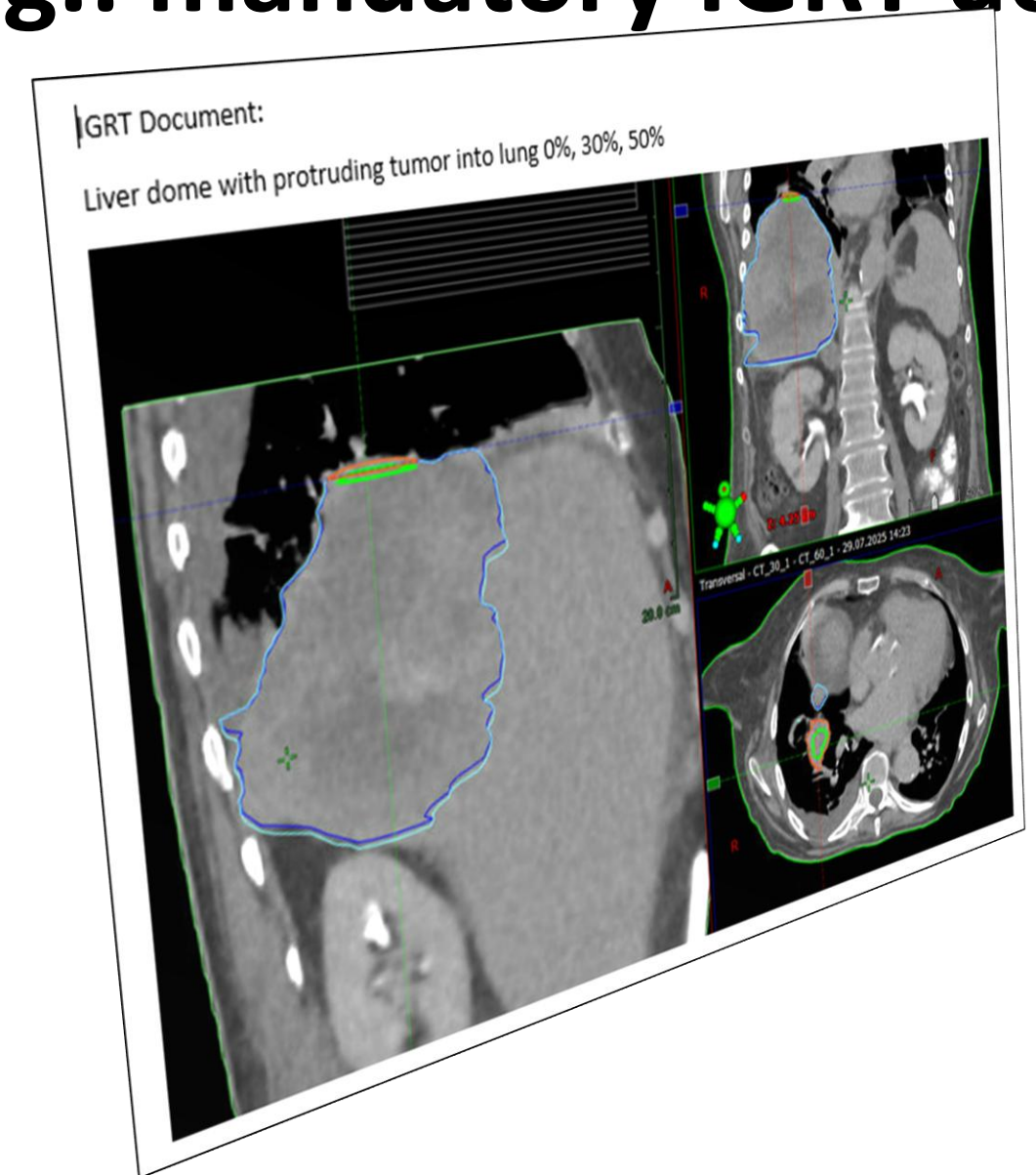
Case 3



Case 4



Suppl. Fig.: mandatory IGRT document



Suppl. Fig. 4e Dose prescription in the TPS

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Treatment Prescription

Prescription Name: Liver 5# SBRT — Approved — History

Site: Liver

Fractions: 5

Prescribe To: Volume — Add

Volume	Total Prescribed Dose (Gy)	Prescribed Dose/ Frac (Gy)
PTV_hep_50	50.000	10.000
ITV_hep_71.86	71.869	14.374
PTV_adr.re_50	50.000	10.000
ITV_adr.re_71.8	71.869	14.374

Primary/Boost: Primary

Mode: Photon

Technique: SBRT

Energy: undefined

Frequency: 3 Times a week

Start: 0 Day(s) None

Other:

Notes: Multiparametric priority ranking: PTV_near_min -> ITV_median -> PTV_0.035 ml; Wilke L. (doi: 10.1007/s00066-021-01799-w) Timmerman

Prescription Coverage Constraints

PTV_hep_50

$D(PTV)_{near\text{-}min}$

Min Dose: Max Dose:

At least: 98.0 % of PTV_hep_50 at 100.0 % of 50.000 Gy = 50.000 Gy

No more than: % of PTV_hep_50 at 153.8 % of 50.000 Gy = 76.900 Gy

$D(PTV)_{near\text{-}max}$

= 65% isodose

ITV_hep_71.86

$D(ITV)50\%$

Min Dose: Max Dose:

At least: 50.0 % of ITV_hep_71.86 at 100.0 % of 71.869 Gy = 71.869 Gy

No more than: % of ITV_hep_71.86 at

PTV_adr.re_50

Min Dose: Max Dose:

At least: 98.0 % of PTV_adr.re_50 at 100.0 % of 50.000 Gy = 50.000 Gy

Organ at Risk Constraints

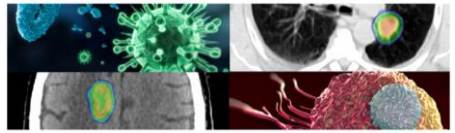
Mean: Gy Max: Gy

< Add Constraint

Multiparametric dose prescription

Parameters	Case 1	Case 2	Case 3			Case 4
Primary tumour	HNSCC	Ewing	Colorectal cancer			CUP –G4 spindle cell
Prescription isodose	65%	65%	60%	65% (bile duct)		65%
Number of fractions	3	5	3	12		5
SIP	n.a.	n.a.	n.a.	PTV_dom	PTV_SIP	n.a.
D98%(PTV) [Gy]	45	50	54	66	46	50
D2%(PTV) [Gy]	69.23	77	90	110	-	77
D50%(ITV) [Gy]	64.7	66.75	84.1	102.8	-	66.75
BED_{10} D98%(PTV) [Gy]	112.5	100	151.2	102.3	63.63	100
BED_{10} D2%(PTV) [Gy]	229	195.58	360	210.83	-	195.58
BED_{10}D50%(ITV) [Gy]	204.24	155.86	319,86	190.87	-	155.86

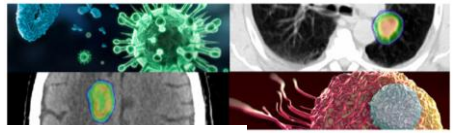
Suppl. Fig: Scripting for Plan analysis



Target Information

Name	Volume	D99%	D98%	D95%	D50%	Dmean	D2%	D1%	D0.035cc	Dmax
ITV_hep_71.86	900.92cc	51.338Gy	52.571Gy	55.428Gy	72.010Gy	69.374Gy	75.398Gy	75.572Gy	76.708Gy	77.207Gy
ITV_adr.re_71.86	16.54cc	58.440Gy	60.060Gy	63.657Gy	72.471Gy	71.262Gy	75.390Gy	75.509Gy	75.672Gy	75.928Gy
GTVm_hep30%	852.86cc	51.867Gy	53.209Gy	56.456Gy	72.281Gy	69.854Gy	75.413Gy	75.585Gy	76.708Gy	77.207Gy
GTVm_adr.re30%	13.14cc	58.223Gy	59.951Gy	63.813Gy	72.875Gy	71.572Gy	75.420Gy	75.530Gy	75.660Gy	75.926Gy
PTV_hep_50	1173.77cc	47.703Gy	48.620Gy	50.234Gy	69.498Gy	65.999Gy	75.318Gy	75.510Gy	76.708Gy	77.207Gy
PTV_adr.re	36.34cc	51.333Gy	52.301Gy	54.112Gy	68.668Gy	66.879Gy	75.192Gy	75.375Gy	75.673Gy	75.928Gy

Suppl. Fig: Scripting for Plan analysis



Structure Information

Structure : ITV_adr.re_71.86

Volume : 16.54 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
D50% > 100%	DoseAtVolume	50 %	72.471 Gy	71.87 Gy	71.869 Gy	PASS	Prescr

Structure : ITV_hep_71.86

Volume : 900.92 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
D50% > 100%	DoseAtVolume	50 %	72.010 Gy	71.87 Gy	71.869 Gy	PASS	Prescr

Structure : PTV_adr.re_50

Volume : 36.34 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
D2% < 153.8%	DoseAtVolume	2 %	75.192 Gy	76.9 Gy	76.9 Gy	PASS	Prescr
D98% > 100%	DoseAtVolume	98 %	52.301 Gy	50 Gy	50 Gy	PASS	Prescr

Structure : PTV_hep_50

Volume : 1173.77 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
D1% < 153.8%	DoseAtVolume	1 %	75.510 Gy	76.9 Gy	76.9 Gy	PASS	Prescr
D98% > 100%	DoseAtVolume	98 %	48.620 Gy	50 Gy	50 Gy	FAIL	Prescr

Structure : Esophagus

Volume : 27.15 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		18.568 Gy	38 Gy	38 Gy	PASS	T
V32.5Gy < 5cc	VolumeAtDose	32.5 Gy	0 cc	5 cc	5 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		18.307 Gy	35 Gy	35 Gy	PASS	D

Structure : Heart

Volume : 818.36 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		33.386 Gy	38 Gy	38 Gy	PASS	T
V32Gy < 15cc	VolumeAtDose	32 Gy	0.125 cc	15 cc	15 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		32.279 Gy	29 Gy	38 Gy	WARN	D

Structure : A_Aorta

Volume : 133.07 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		25.795 Gy	53 Gy	53 Gy	PASS	T
V47Gy < 10cc	VolumeAtDose	47 Gy	0 cc	10 cc	10 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		25.523 Gy	53 Gy	53 Gy	PASS	D

Structure : V_Venacava_I

Volume : 77.37 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		54.613 Gy	53 Gy	53 Gy	FAIL	T
V47Gy < 10cc	VolumeAtDose	47 Gy	0.693 cc	10 cc	10 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		52.732 Gy	53 Gy	53 Gy	PASS	D

Structure : Bronchus

Volume : 4.63 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		35.638 Gy	40 Gy	40 Gy	PASS	T
V32Gy < 0.5cc	VolumeAtDose	32 Gy	0.319 cc	0.5 cc	0.5 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		34.228 Gy	35 Gy	38 Gy	PASS	D

Structure : Skin

Volume : 1589.37 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		38.488 Gy	38.5 Gy	38.5 Gy	PASS	T
V36.5Gy < 10cc	VolumeAtDose	36.5 Gy	8.34 cc	10 cc	10 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		38.332 Gy	39.5 Gy	-------- Gy	PASS	D
D10cc < 36.5 Gy	DoseAtVolume	10 cc	36.295 Gy	36.5 Gy	-------- Gy	PASS	D

Structure : Stomach

Volume : 220.61 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
MaxDose[0.035ccm]	MaxDose		15.576 Gy	35 Gy	35 Gy	PASS	T
V26.5Gy < 5cc	VolumeAtDose	26.5 Gy	0 cc	5 cc	5 cc	PASS	T
MaxDose[0.1ccm]	MaxDose		15.303 Gy	33 Gy	35 Gy	PASS	D
D10cc < 25 Gy	DoseAtVolume	10 cc	11.518 Gy	25 Gy	-------- Gy	PASS	D
D50cc < 12 Gy	DoseAtVolume	50 cc	8.572 Gy	12 Gy	-------- Gy	PASS	D

Structure : Liver

Volume : 3133.71 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
CV21.5Gy > 700cc or 1/3	CriticalVolumeAtDose	21.5 Gy	1434.5 cc	1044.57 cc	1044.57 cc	PASS	T
CV15.0Gy > 700cc	CriticalVolumeAtDose	15 Gy	1112.0 cc	700 cc	-------- cc	PASS	D
V10Gy < 70%	VolumeAtDose	10 Gy	72.526 %	70 %	-------- %	WARN	D
Dmean < 13Gy	MeanDose		32.586 Gy	13 Gy	15.2 Gy	FAIL	D

Structure : Kidney_L

Volume : 269.46 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
Dmean < 10Gy	MeanDose		3.654 Gy	10 Gy	-------- Gy	PASS	D
V10Gy < 10%	VolumeAtDose	10 Gy	2.93 %	10 %	45 %	PASS	D

Structure : Kidney_R

Volume : 200.11 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
Dmean < 10Gy	MeanDose		7.352 Gy	10 Gy	-------- Gy	PASS	D
V10Gy < 10%	VolumeAtDose	10 Gy	17.02 %	10 %	45 %	WARN	D

Structure : Kidneys (auto-generated)

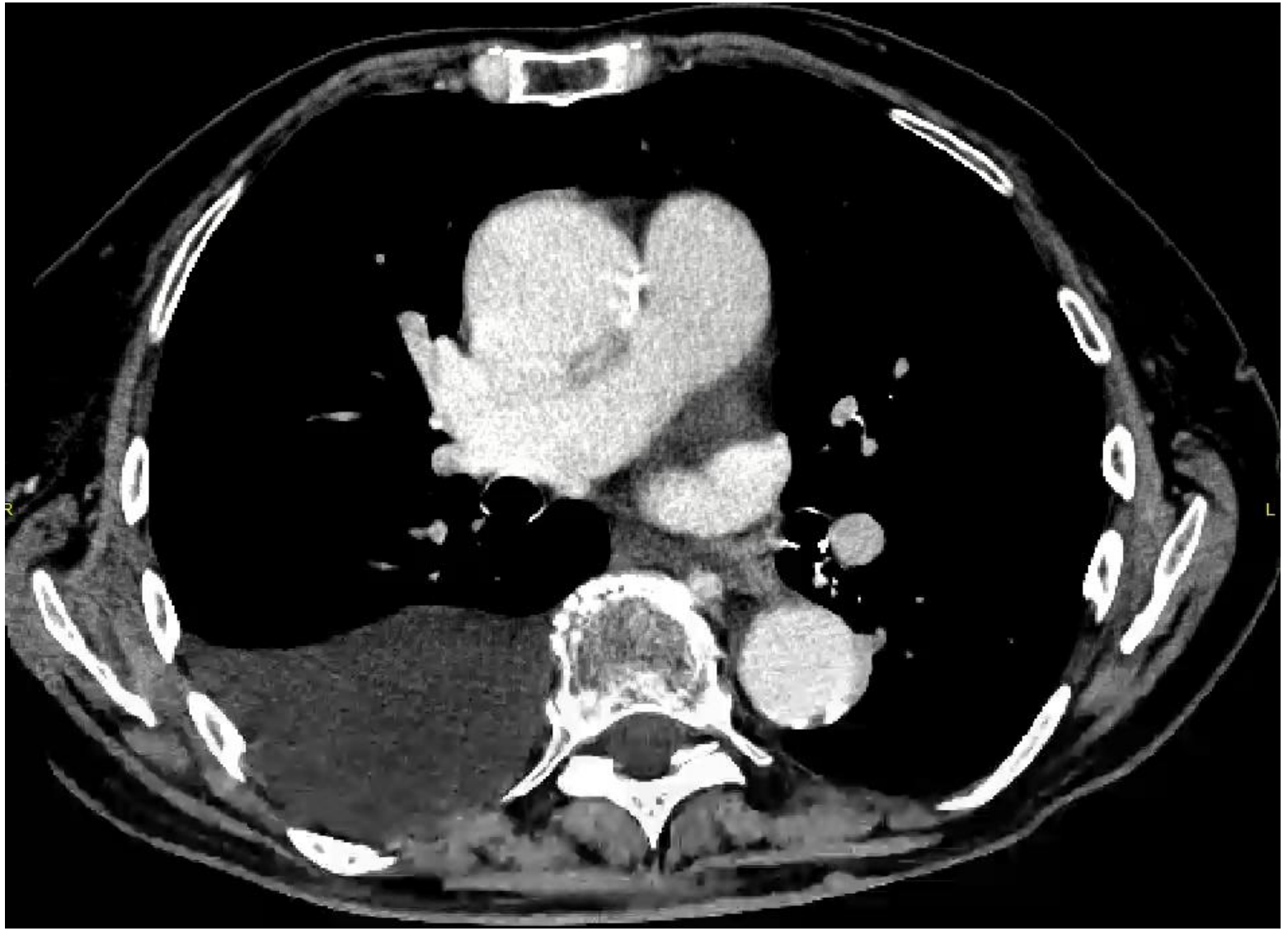
Volume : 469.25 cc

Name	Type	Evaluation Point	Calculated Value	Goal	Must	Evaluation	Ref
CV17.5Gy > 200cc or 1/3	CriticalVolumeAtDose	17.5 Gy	444.0 cc	200 cc	200 cc	PASS	T,D
Dmean < 10Gy	MeanDose		5.230 Gy	10 Gy	-------- Gy	PASS	D

References

[T]...Timmermann, R.: A Story of Hypofractionation and the Table on the Wall
[D]...Diez, P.: UK 2022 Consensus on Normal Tissue Dose-Volume Constraints for Oligometastatic, Primary Lung and Hepatocellular Carcinoma Stereotactic Ablative Radiotherapy

Suppl. Fig: Follow-up



Plane	Before SBRT [cm]	SBRT + 6 mts [cm]
cc	12.4	6.7
ds	10.1	9.3
vd	11.2	6.9

Discussion

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Discussion Indication

Case 1

Indication:

The indication for case 1 was for a synchronous oligometastatic disease with a solitary metastasis in segment 8. The diagnosis of the liver metastasis was made during definitive chemoradiotherapy for the oropharyngeal cancer. In the light of the positive data on oligometastasis in head and neck cancer this small liver metastasis with favourable location was estimated to be an excellent indication for ablative SBRT (Rühle et al.). Nevertheless, follow-up showed 4 months after completion of SBRT, that the patient had early progressive disease in the lung, the liver, the left kidney and in a celiac trunk lymph node. This rapid progression is in line with the less favourable predictive value of synchronous oligometastasis.

Case 2

The 32-year old patient (case 2) was referred for an initially polymetastatic induced OMD of a Ewing sarcoma. Induced OMD has a less favourable prognosis compared to primary oligometastatic disease meaning that indications need to be established more cautiously in this situation. Young age certainly is a strong motivator for metastasis directed therapy and SBRT is often the method of choice over surgery and other ablative methods because of its non-invasiveness and good tolerance. The patient progressed immediately after the end of SBRT in the pelvis reflecting the particularly highly aggressive nature of an induced oligometastasis in Ewing sarcoma.

Case 3

Case 3 is also an induced OMD. However, this patient had colorectal cancer (CRC) with successful surgical and radiofrequency therapy four years prior to an induced oligoprogression. CRC is known to benefit strongly from metastasis directed therapy with best evidence from surgical approaches. On the other hand, the patient had 4 liver metastases placing him on the upper range of the classical OMD definition ranging up to 5 lesions. The central location in segment five at the hepatic hilum was a strong argument for SBRT to prevent liver failure from further progression in that critical location. The strongest argument to go for SBRT was the long interval between the first diagnosis and the single organ relapse. Nine months after the end of SBRT the patient had complete response of all liver lesions with no systemic therapy after completion of SBRT. He had no side effects from the treatment.

Case 4

The last case (case 4) presented is a 84 year old lady with a monstruous liver lesion infiltrating through the diaphragma into the basal aspects of the lung plus a right-sided adrenal metastasis. It is not fully clear, whether this is a cancer of the unknown primary or a primary liver cancer with an uncommon histology of an undifferentiated spindle cell carcinoma. Therefore, the ESTRO-EORTC classification needs to be seen cautiously. The elderly patient was not fit for systemic therapy and SBRT was the only local method available. The patient was fit enough for SBRT and the location of

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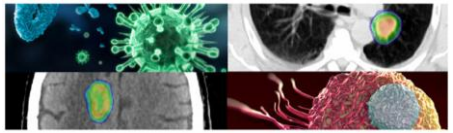


Discussion: Structure

- Indication
- Pre-SBRT image Staging
- Fiducial markers
- Motion management
- Planning CT scan
- Image fusion of diagnostic scans
- Segmentation
- IGRT preparation
- Choice of fraction number
- Multiparametric dose prescription
- OAR dose constraints
- Planning and plan analysis
- Treatment fractions
- Follow-up

Discussion

Multiparametric Dose Prescription:

Case 1

Multiparametric dose prescription:

Dose prescription for non-colorectal cancer liver metastases is standardised in our institution to the 65% isodose to a near-minimal dose to the PTV: D(PTV)98% = 45 Gy in 3 fractions (BED_{10} = 112.5 Gy). This results in a D(PTV)2% of 229 Gy BED_{10} and a D(ITV)50% of 204.24 Gy BED_{10}. We chose to prescribe the median dose to the ITV rather than to the GTV (Moustakis et al.) because we are treating in free breathing and we aim to achieve good dose coverage to the median of the macroscopic tumour in all breathing phases.

Case 2

As in case 1 and for the same reasons, the 65% isodose was used in case 2 and the same relative dose to D(ITV)50%. This resulted in D(PTV)98% = 50 Gy in 5 fractions (BED_{10} = 100 Gy) and a D(PTV)2% of 195.2 Gy BED_{10} and a D(ITV)50% of 175.2 Gy BED_{10}.

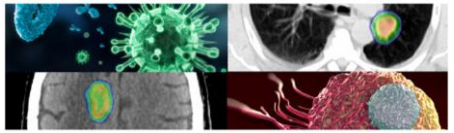
Case 3

Dose escalation was intended in case 3 because of the histology of a colorectal cancer primary. This was straightforward for the lesion in segment 8 with the 60% isodose to D(PTV)98% in three fractions (3 x 18 Gy) resulting in a BED_{10} = 151.2 Gy and a D(PTV)2% of 360 Gy BED_{10} as well as a D(ITV)50% of 319.6 Gy BED_{10}. However, the lesions in segments 4 and 5 had to be mutually compatible with the close proximity to the colon, the duodenum and the common bile duct. To achieve this, we chose the 65% isodose and 12 x 5.5 Gy to D(PTV)98% resulting in a BED_{10} = 102.3 Gy and a D(PTV)2% of 187.4 Gy BED_{10} as well as a D(ITV)50% of 169.9 Gy BED_{10}. This certainly is a compromise, but the relatively high median dose to the ITV appeared to be good in order to achieve local control and adequate protection of the organs at risk. We believe that this is an excellent example for the importance of multiparametric dose prescription.

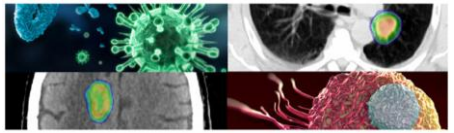
In case 3, multi-parametric prescription additionally had a dose prescription to the PTV subvolume, PTV_{SIP}. We prescribed a D(PTV_{SIP})50% of 46 Gy which would allow to have a steep dose gradient with in that sub- volume with a higher dose towards the ITV and a lower dose towards the bowel structures. It is important to stress, that a specific dose should be prescribed to PTV_{SIP} to avoid that this subvolume does not receive sufficient dose. The aim is to achieve those as high as possible whilst being in line with the dose constraints.

Case 4

In case 4, the prescription isodose and the relative dose to D(ITV)50% were defined as for case 2. This resulted in the same BED values as in case 2 but in a much larger PTV (1174 cc vs 105 cc). The same dose prescription was used for the right adrenal metastasis which was in direct contact with the PTV of the liver lesion.

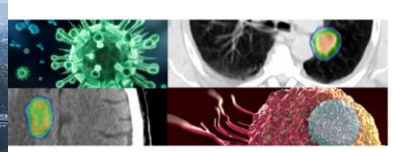


Conclusion



1. Choice of 4 very different cases of liver metastases in many respects
2. Abundant image documentation of all cases in the manuscript and in the supplementary figures & videos
3. Extensive discussion of all aspects as defined by DEGRO AG STX / DGMP AK 21 from indication through follow-up
4. References of relevant papers

Thank you very much for your attention!



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Vielen Dank für Ihre Aufmerksamkeit!

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