



**UNIVERSITY OF KRAGUJEVAC
FACULTY OF MEDICAL SCIENCES**



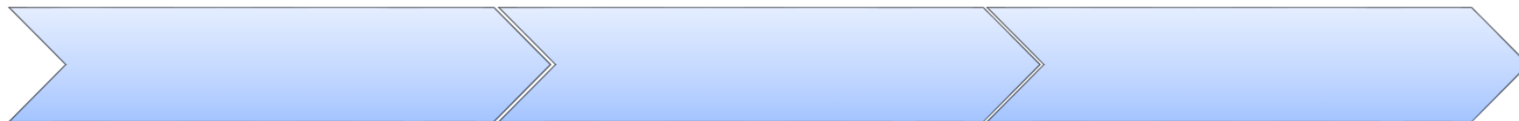
BASIC CLINICAL RADIATION ONCOLOGY

**Assist. professor Marija Živković Radojević, MD, PhD
Center for Radiation Oncology, University Clinical Center Kragujevac**

Kragujevac, 2023

Basic steps in the implementation of radiotherapy treatment

- Multidisciplinary tumor medical board (TMB) decision
- First examination and interview
- Preparation for CT simulation / processing
- CT simulation
- Delineation of organs at risk (OAR) and target volumes
- Radiotherapy planning
- Accuracy check and plan verification
- Positioning
- Treatment implementation
- Quality assurance procedures
- Monitoring of side effects during and after completed radiotherapy treatment

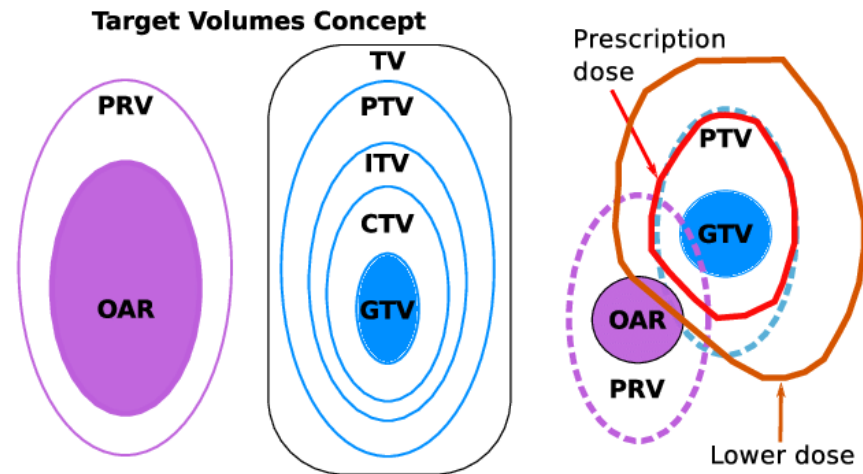


Radiotherapy application

- External beam radiotherapy (EBRT)
- Brachytherapy

Radiotherapy techniques

- 1D radiotherapy
- 2D - conventional radiotherapy
- 3D - conformal radiotherapy (3D-CRT)
- Intensity modulated radiotherapy (IMRT)
- Volumetric modulated arc radiotherapy (VMAT)
- Image-guided radiotherapy (IGRT)
- Stereotactic radiotherapy
- Stereotactic radiosurgery
- Intraoperative radiotherapy
- Particle Beam Therapy



Schlachter R, Raidou R, Muren LP, Preim B. State-of-the-Art Report: Visual Computing in Radiation Therapy Planning. Computer Graphics Forum 2019;38: 753-779.

Application of radiotherapy depending on localization

- Breast cancer
- Lung cancer
- Gynecological malignancies
- Urogenital tumors
- Digestive tract tumors
- Lymphomas and leukemias
- CNS tumors
- Skin and soft tissue tumors
- Head and neck tumors
- Tumors in elderly
- Pediatric tumors

Radiotherapy of gynecological malignancies

- EBRT (2D-conventional, 3D-CRT, IMRT, VMAT)
- 2D or 3D brachytherapy (intracavitary and/or interstitial)

Vulvar cancer FIGO classification (2021)

Lymphatic drainage of the vulva

Vulvar cancer radiotherapy

Radical RT +/- CHT potentiation by cisplatin

Contraindications for surgery

Inoperable tumors, T3-T4, N3

Standard:

Regime I (technique I) : 45Gy, 2Gy per fraction + Boost (e-) 10-20Gy, 2Gy per fraction

Regime II (technique II): 55-65Gy, 1.8-2 Gy per fraction (max. dose: vulva up to 65Gy, inguinum up to 55Gy possibility of split course)

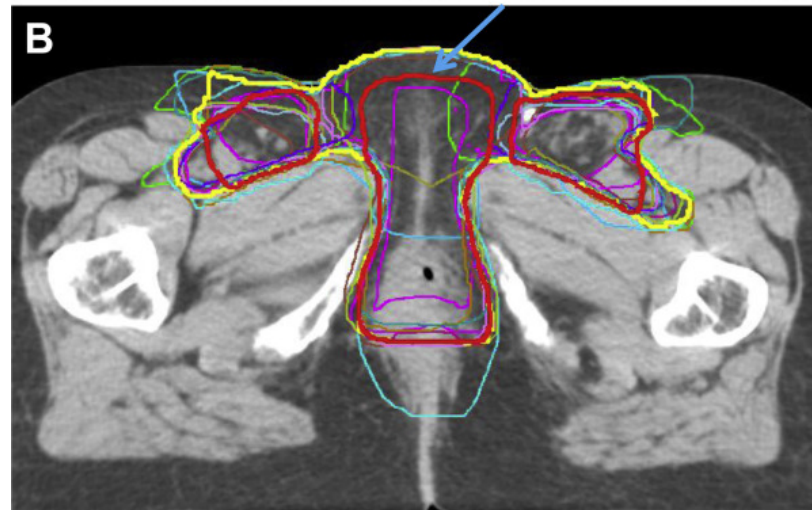
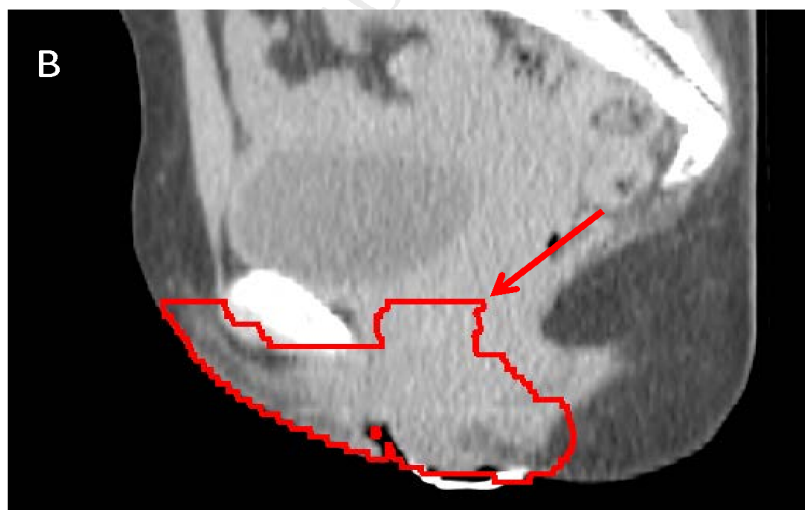
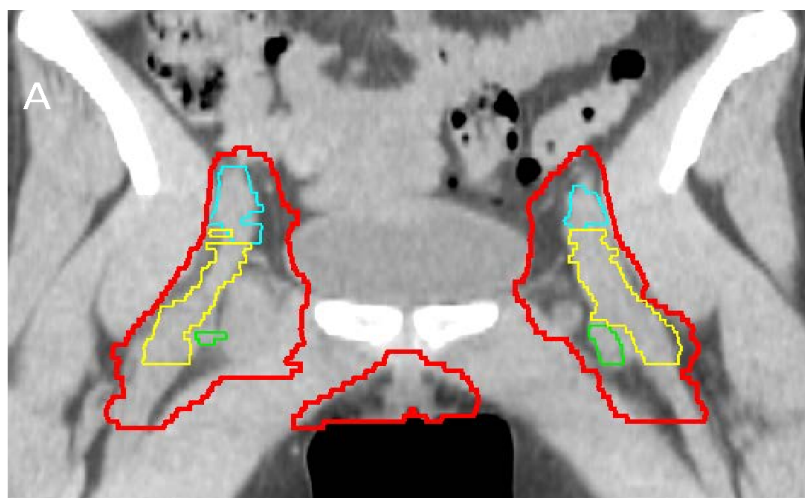
Non-standard: TD 45Gy (AP- PA fields + electrons on inguinum) + boost(s) (inguinum+ perineum) 10-20Gy, 1.8-2Gy

Postoperative RT (start within 6 weeks of surgery)

High-risk group, positive resection margins or insufficient margins (optimally 1-2cm), positive inguinal nodes

Regimen I: 45-50Gy,(e) direct fields, 1.8-2 Gy per fraction

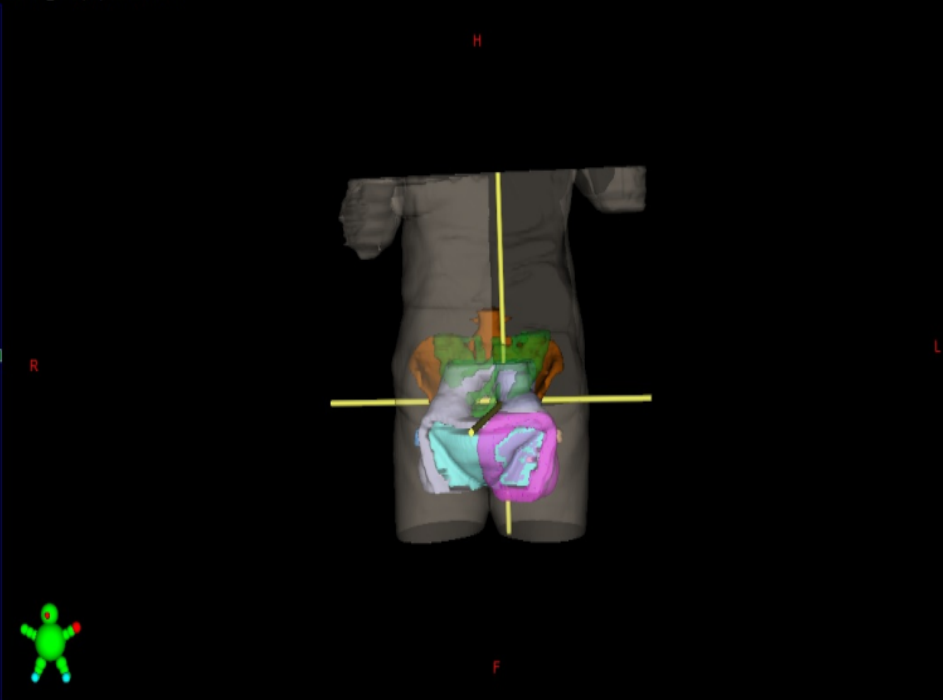
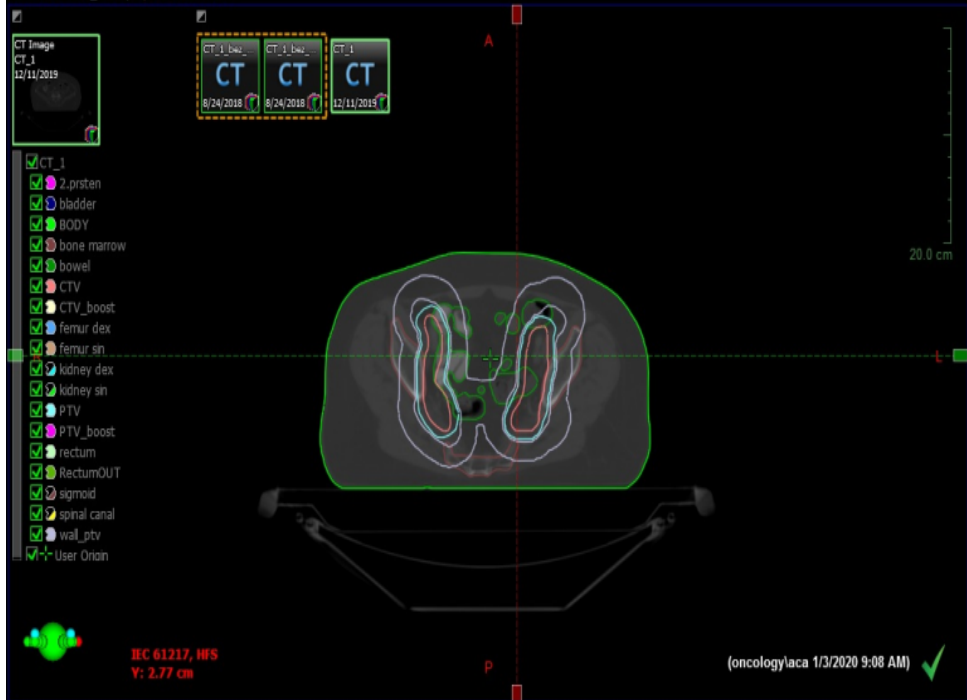
Regime II: 45Gy, (photons), pelvic fields, 2Gy per fraction, all fields + Boost (e) 10-20Gy, 2Gy per fraction



Gaffney DK, et al. Consensus Recommendations for Radiation Therapy Contouring and Treatment of Vulvar Carcinoma. *Int J Radiat Oncol Biol Phys* 2016;95(4):1191-200.

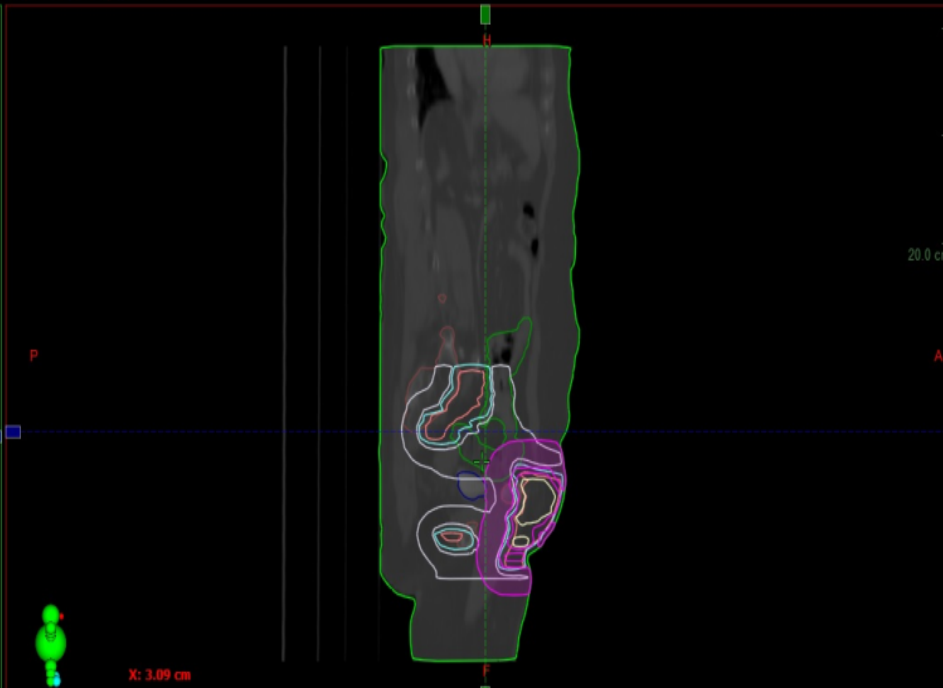
Transversal - CT_1 - 12/11/2019 10:01 AM

3D - CT_1 - 12/11/2019 10:01 AM



Frontal - CT_1 - 12/11/2019 10:01 AM

Sagittal - CT_1 - 12/11/2019 10:01 AM



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3D MAX for PTV: 108.2 %

3D MIN for PTV: 68.0 %

3D MEAN for PTV: 100.7 %

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Head First-Supine

Y: -6.73 cm

ymat - Treatment Approved - Frontal - CT 1

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Z: -3.17 cm

X: 5.84 cm

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3D MEAN for PTV: 100.7 %

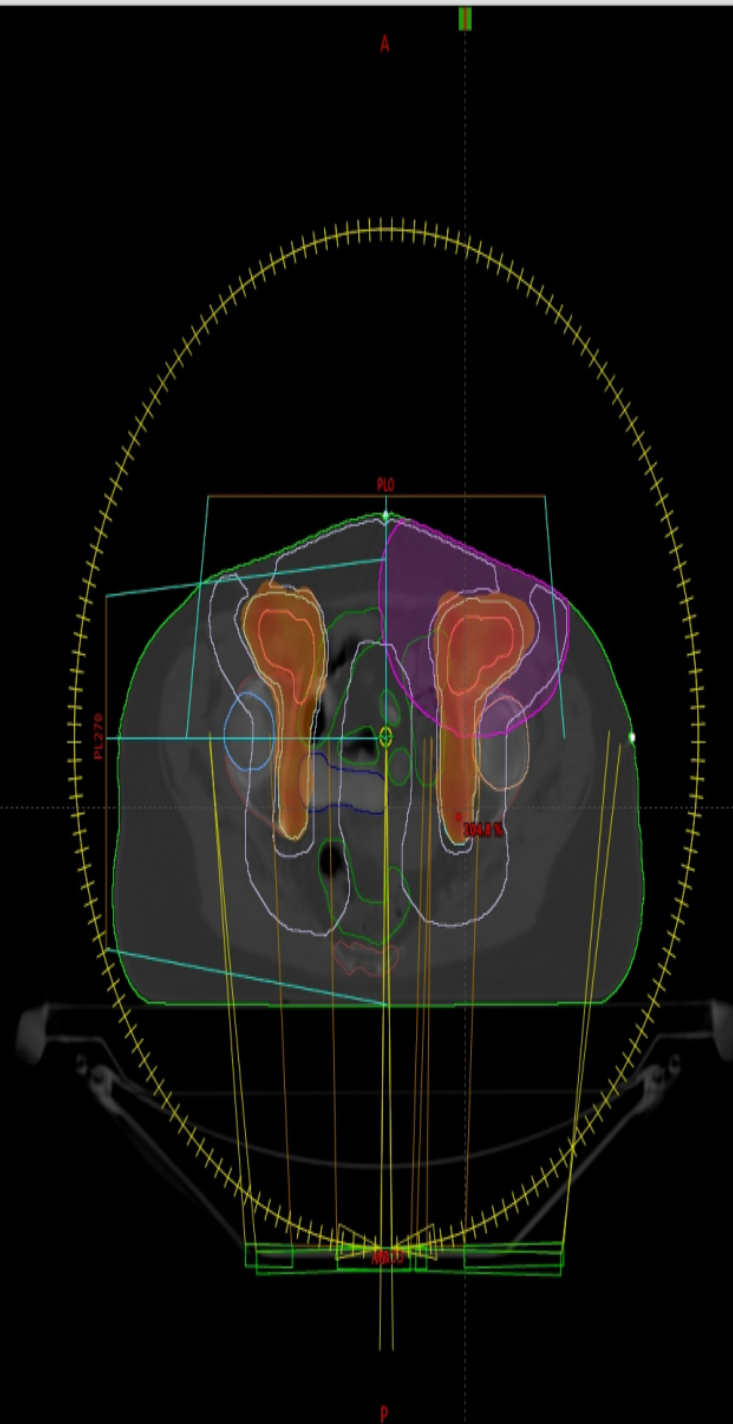
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Head First-Supine
V: 0.27 cm



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3D MIN for PTV: 68.0 %
3D MEAN for PTV: 100.7 %

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Head First-Supine
Y: -1.23 cm

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vmat

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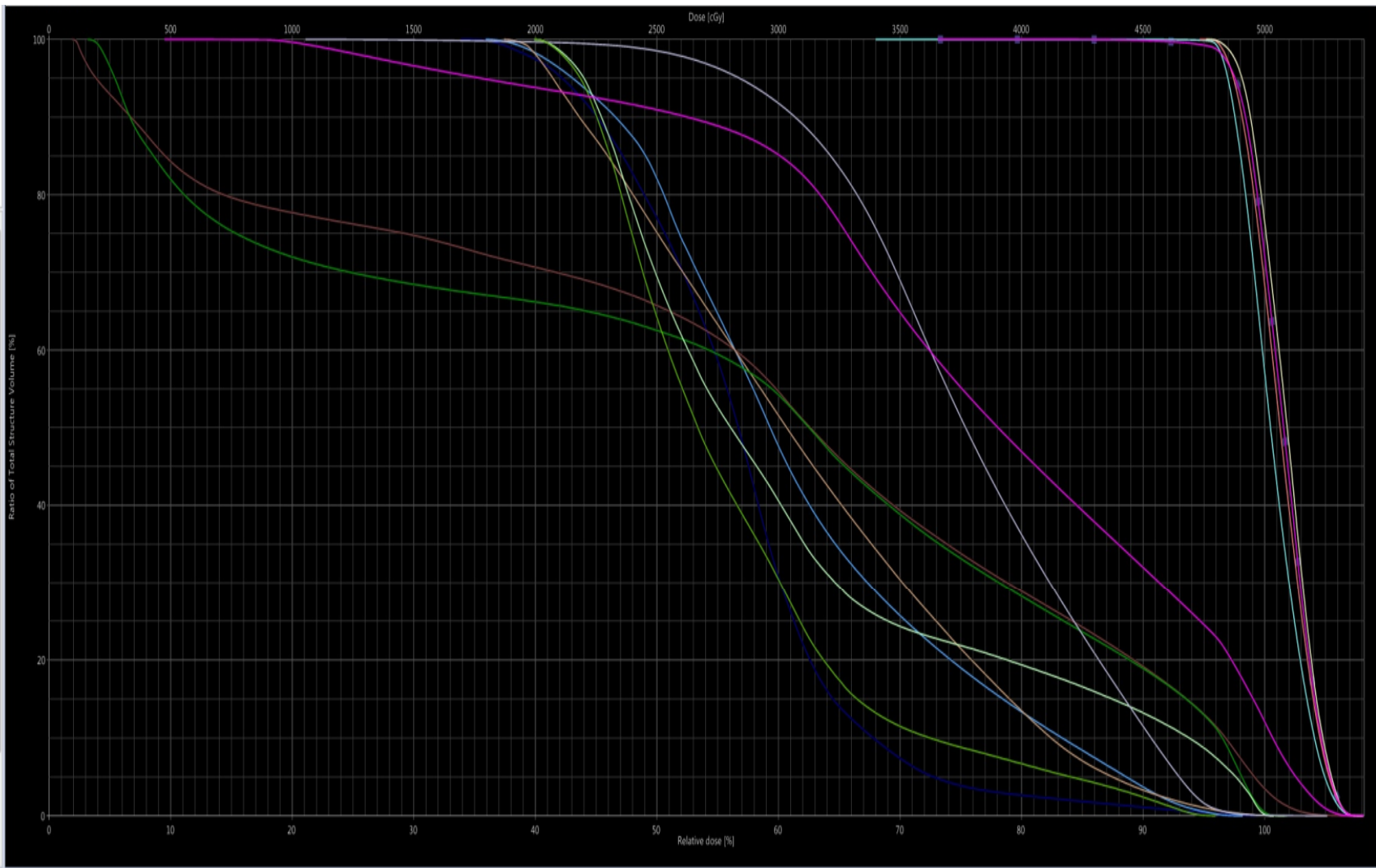
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PTV
PTV_boost
rectum
RectumOUT
sigmoid
spinal canal
wall_ptv
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Reference Points
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PL270-DRR (Live)
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Dose Reference Points Dose Statistics												
Show DVH	Structure	Approval Status	Plan	Course	Volume [cm ³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]	V50.0 [%]	V4750.0 cGy [%]
<input checked="" type="checkbox"/>	BODY	Approved	vmat	1	41447.3	100.0	100.0	0.0	108.2	22.4	19.6	5.2
<input checked="" type="checkbox"/>	bladder	Approved	vmat	1	106.9	100.0	100.0	33.9	99.3	56.8	77.0	0.4
<input checked="" type="checkbox"/>	bone marrow	Approved	vmat	1	1314.2	100.0	100.0	1.9	107.3	56.9	65.7	13.1
<input checked="" type="checkbox"/>	bowel	Approved	vmat	1	910.2	100.0	100.0	3.2	101.9	54.5	62.5	12.9
<input checked="" type="checkbox"/>	CTV	Approved	vmat	1	1087.4	100.0	100.0	94.7	108.2	101.3	100.0	100.0
<input checked="" type="checkbox"/>	femur dex	Approved	vmat	1	102.8	100.0	100.0	36.0	98.2	62.0	82.1	0.6
<input checked="" type="checkbox"/>	femur sin	Approved	vmat	1	93.9	100.0	100.0	37.4	101.6	62.1	75.1	1.1
<input checked="" type="checkbox"/>	PTV	Approved	vmat	1	1849.5	100.0	100.0	68.0	108.2	100.7	100.0	99.9
<input checked="" type="checkbox"/>	rectum	Approved	vmat	1	60.7	100.0	100.0	40.0	100.8	61.9	69.4	8.7
<input checked="" type="checkbox"/>	wall_ptv	Approved	vmat	1	2489.8	100.0	100.0	21.1	105.2	75.6	98.5	1.6
<input checked="" type="checkbox"/>	RectumOUT	Approved	vmat	1	51.8	100.0	100.0	40.0	96.0	56.5	64.2	0.1
<input checked="" type="checkbox"/>	2.prsten	Approved	vmat	1	1023.9	100.0	100.0	9.5	107.9	77.2	91.0	24.5
<input checked="" type="checkbox"/>	CTV_boost	Approved	vmat	1	189.6	100.0	100.0	95.2	108.0	101.8	100.0	100.0
<input checked="" type="checkbox"/>	PTV_boost	Approved	vmat	1	304.6	100.0	100.0	73.1	108.2	101.5	100.0	99.3

Interstitial brachytherapy of the vulva

- Monotherapy - tumors up to 2 cm (T1N0M0)
- EBRT+IS BT (to the tumor bed)
- Palliative approach and salvage brachytherapy (local recurrence)

Vaginal cancer - FIGO classification

TABLE 1 Comparison of staging systems for vaginal cancer

AJCC Stage	Stage grouping (TNM)	FIGO Stage	Stage description
IA	T1a N0 M0	I	The cancer is only in the vagina and is no larger than 2.0 cm (4/5 inch) (T1a) It has not spread to nearby lymph nodes (N0) or to distant sites (M0)
IB	T1b N0 M0	I	The cancer is only in the vagina and is larger than 2.0 cm (4/5 inch) (T1b) It has not spread to nearby lymph nodes (N0) or to distant sites (M0)
IIA	T2a N0 M0	II	The cancer has grown through the vaginal wall, but not as far as the pelvic wall and is no larger than 2.0 cm (4/5 inch) (T2a) It has not spread to nearby lymph nodes (N0) or to distant sites (M0)
IIB	T2b N0 M0	II	The cancer has grown through the vaginal wall, but not as far as the pelvic wall and is larger than 2.0 cm (4/5 inch) (T2b) It has not spread to nearby lymph nodes (N0) or to distant sites (M0)
III	T1 to T3 N1 M0	III	The cancer can be any size and might be growing into the pelvic wall, and/or growing into the lower one-third of the vagina and/or has blocked the flow of urine (hydronephrosis), which is causing kidney problems (T1 to T3). It has also spread to nearby lymph nodes in the pelvis or groin (inguinal) area (N1) but not distant sites (M0)
	OR T3 N0 M0	III	The cancer is growing into the pelvic wall, and/or growing into the lower one-third of the vagina and/or has blocked the flow of urine (hydronephrosis), which is causing kidney problems (T3) It has not spread to nearby lymph nodes (N0) or to distant sites (M0)
IVA	T4 Any N M0	IVA	The cancer is growing into the bladder or rectum or is growing out of the pelvis (T4) It might or might not have spread to lymph nodes in the pelvis or groin (inguinal area) (Any N). It has not spread to distant sites (M0)
IVB	Any T Any N M1	IVB	The cancer has spread to distant organs such as the lungs or bones (M1). It can be any size and might or might not have grown into nearby structures or organs (Any T) It might or might not have spread to nearby lymph nodes (Any N)

Vaginal cancer radiotherapy

Radical radiotherapy or postoperative +/- CHT potentiation

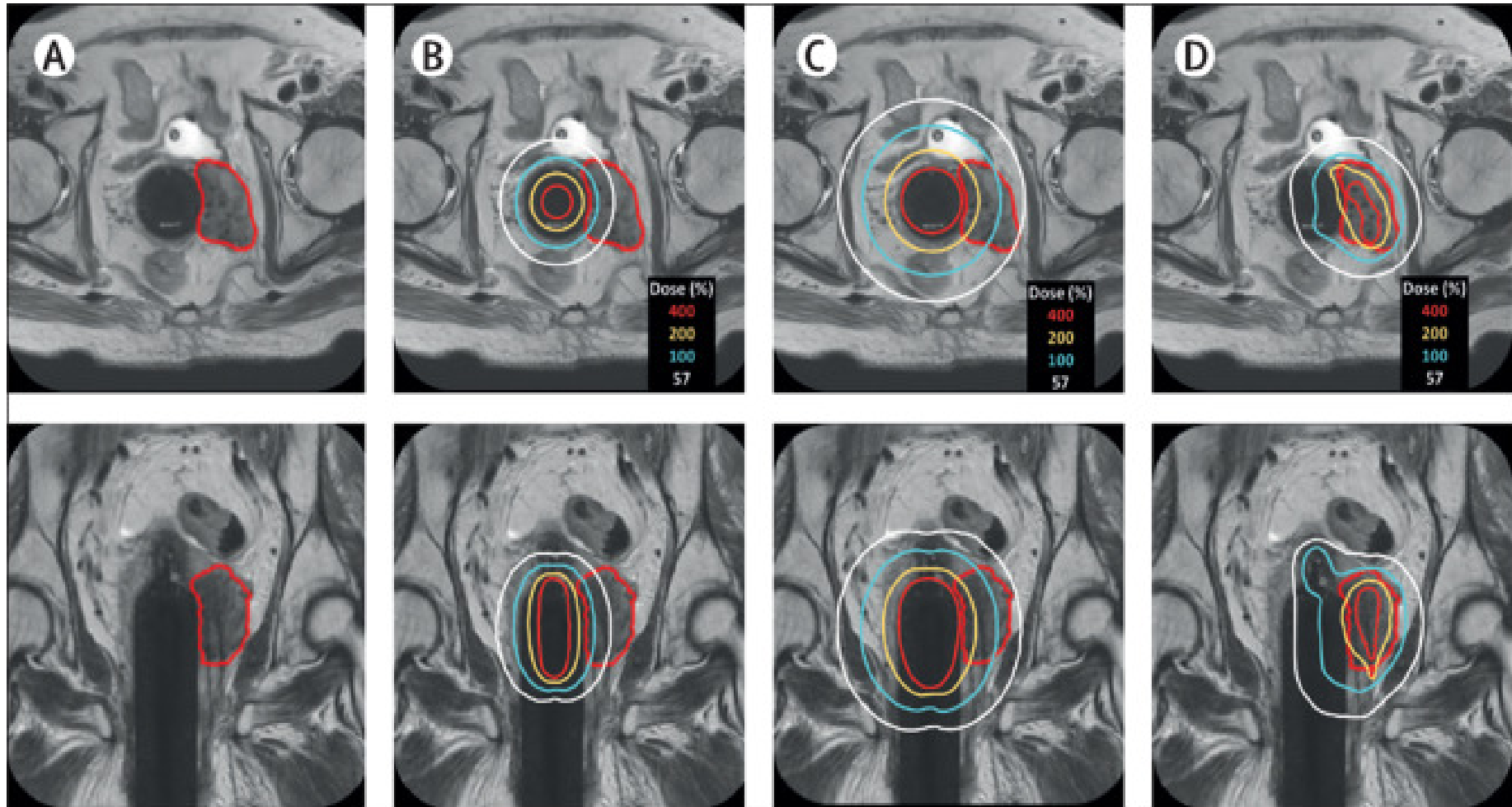
- Stage I (infiltration of more than 0.5 cm of mucosa) - IVA
- Adjuvant RT after tumor excision (abnormal)

Standard: 46Gy, 1.8-2Gy per day, 5 days/week

- Boost on enlarged inguinal lymphatic(s): up to max 15-20Gy in 7-10 fractions
- Brachytherapy: after 5-10 fractions of EBRT

Non-standard:

- Hemostatic application (before EBRT)
- In advanced tumors with altered topographic relationships after 30Gy EBRT or after completed EBRT



Westerveld H, et al. Definitive radiotherapy with image-guided adaptive brachytherapy for primary vaginal cancer. *Lancet Oncol* 2020;21(3):e157-67.

Miami applicators

Staging of Cervical Cancer

TABLE I: International Federation of Gynecology and Obstetrics Staging of Cervical Cancer 2018

Stage	Description
I	Tumor confined to the uterus
IA	Invasive carcinoma (diagnosed microscopically) with maximum depth of invasion < 5 mm
IA1	Measured stromal invasion < 3 mm in depth
IA2	Measured stromal invasion \geq 3 mm and < 5 mm in depth
IB	Invasive carcinoma with depth of invasion \geq 5 mm, limited to cervix uteri
IB1	Invasive carcinoma with \geq 5 mm stromal invasion and < 2 cm in greatest dimension
IB2	Invasive carcinoma \geq 2 cm and < 4 cm in greatest dimension
IB3	Invasive carcinoma \geq 4 cm in greatest dimension
II	Tumor invades outside uterus but not pelvic sidewall
IIA	Without parametrial invasion
IIA1	Invasive carcinoma \leq 4 cm in greatest dimension
IIA2	Invasive carcinoma \geq 4 cm in greatest dimension
IIB	With parametrial invasion
III	Tumor invades pelvic sidewall and lower third of vagina, affecting kidney
IIIA	Tumor invades lower third of vagina without pelvic sidewall involvement
IIIB	Tumor invades pelvic sidewall or causes hydronephrosis
IIIC	Tumor involves pelvic or paraaortic lymph nodes, or both, irrespective of tumor size and extent
IIIC1	Pelvic lymph node metastasis only
IIIC2	Paraaortic lymph node metastasis
IV	Bladder or rectal invasion
IVA	Invades mucosa of bladder or rectum
IVB	Spread to distant organs

Radiotherapy of locally advanced cervical cancer

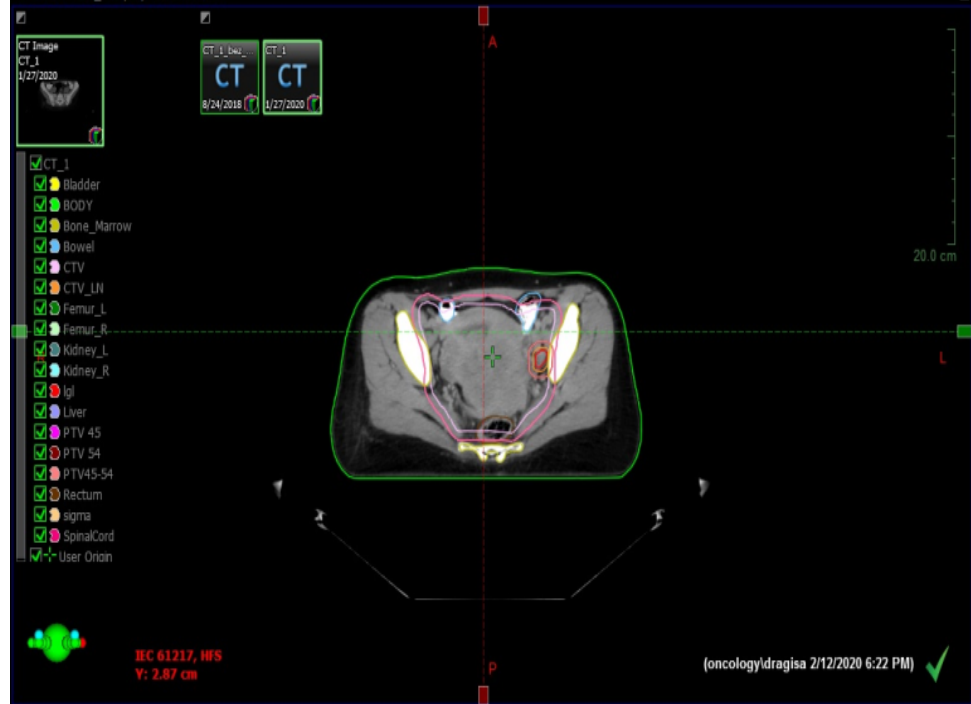
FIGO St. IB bulky, IIA, IIB – IVA

Patient refuses surgery (in the early stages)

- **RT+CHT potentiation (standard) + brachytherapy**
 - Standard: 46Gy, 1.8-2Gy per fraction, 5 days/week
 - Boost to parameters (tumor rest) 5Gy
 - Boost on enlarged inguinal lymphatics: up to max 55Gy
 - Prophylactic RT of the para-aortic region up to L3: TD 45 Gy, 1.8 Gy per fraction
 - Para-aortic region: 45Gy, 5 days/week, 1.8 Gy per fraction
-
- Palliative doses: 30 Gy in 10 fractions, 20 Gy in 5 fractions
 - Nodal boost:
 - 55Gy pelvic lymphatics simultaneous integrated boost (SIB) – within 25 fractions / sequential up to a total dose with a daily dose of 1.8Gy
 - 57.5Gy – 60Gy para-aortic lymphatics SIB - within 25 fractions / sequential up to a total dose with a daily dose of 1.8Gy

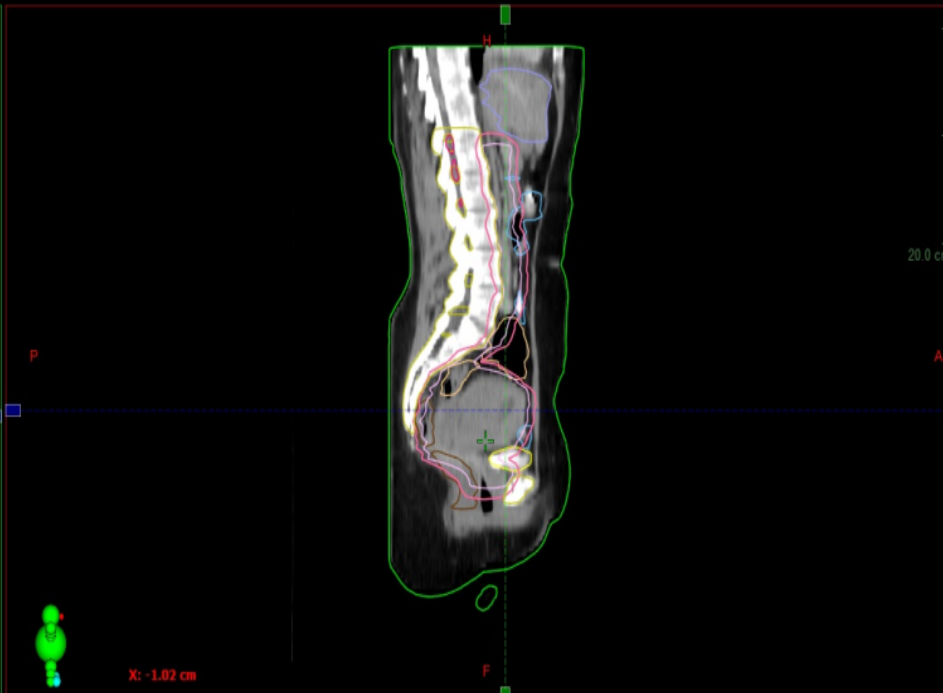
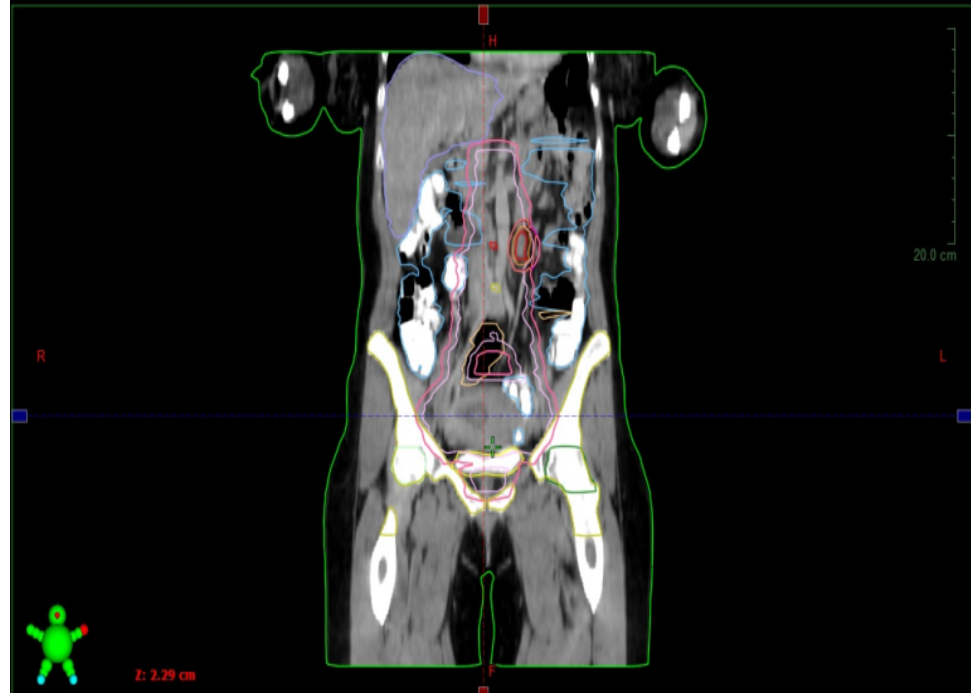
Transversal - CT_1 - 1/27/2020 10:32 AM

3D - CT_1 - 1/27/2020 10:32 AM



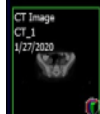
Frontal - CT_1 - 1/27/2020 10:32 AM

Sagittal - CT_1 - 1/27/2020 10:32 AM

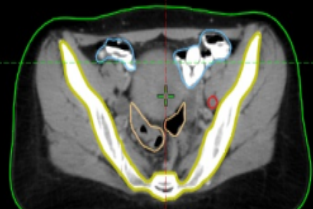


Transversal - CT_1 - 1/27/2020 10:32 AM

3D - CT_1 - 1/27/2020 10:32 AM



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- ☒ BODY
- ☒ Bone_Marrow
- ☒ Bowel
- ☐ CTV
- ☐ CTV_UN
- ☒ Femur_L
- ☒ Femur_R
- ☒ Kidney_L
- ☒ Kidney_R
- ☒ Igl
- ☒ Liver
- ☐ PTV 45
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- ☒ Rectum
- ☒ sigma
- ☒ SpinalCord
- ☒ User Origin

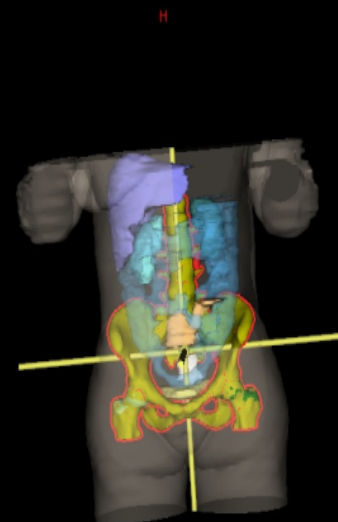


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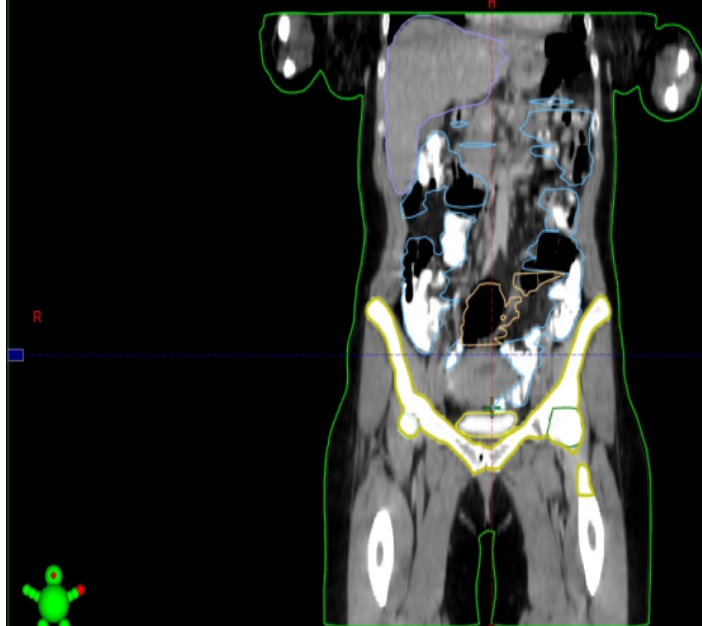
DEC 61217, HFS
Y: 4.87 cm

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Frontal - CT_1 - 1/27/2020 10:32 AM

Sagittal - CT_1 - 1/27/2020 10:32 AM



20.0 cm



Z: 3.05 cm



20.0 cm



X: 0.00 cm

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3D MAX for PTV45-54: 100.4 %
3D MIN for PTV45-54: 69.2 %
3D MEAN for PTV45-54: 83.4 %

R L

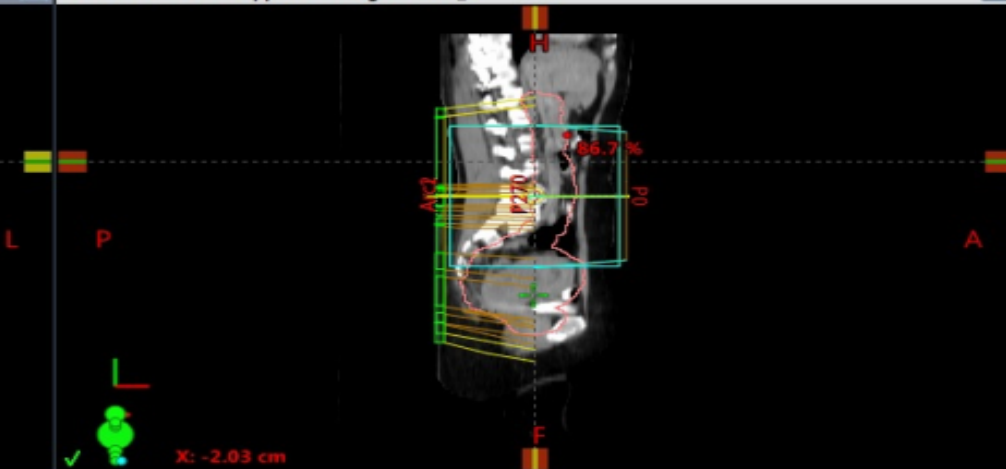
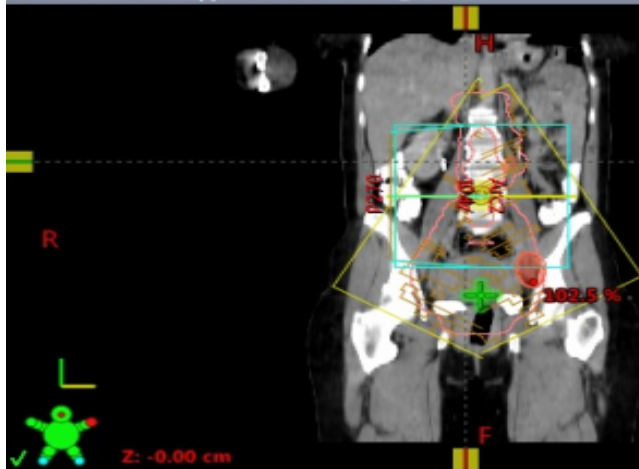
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Head First-Supine
Y: 18.88 cm

Plan2 - Treatment Approved - Frontal - CT_1

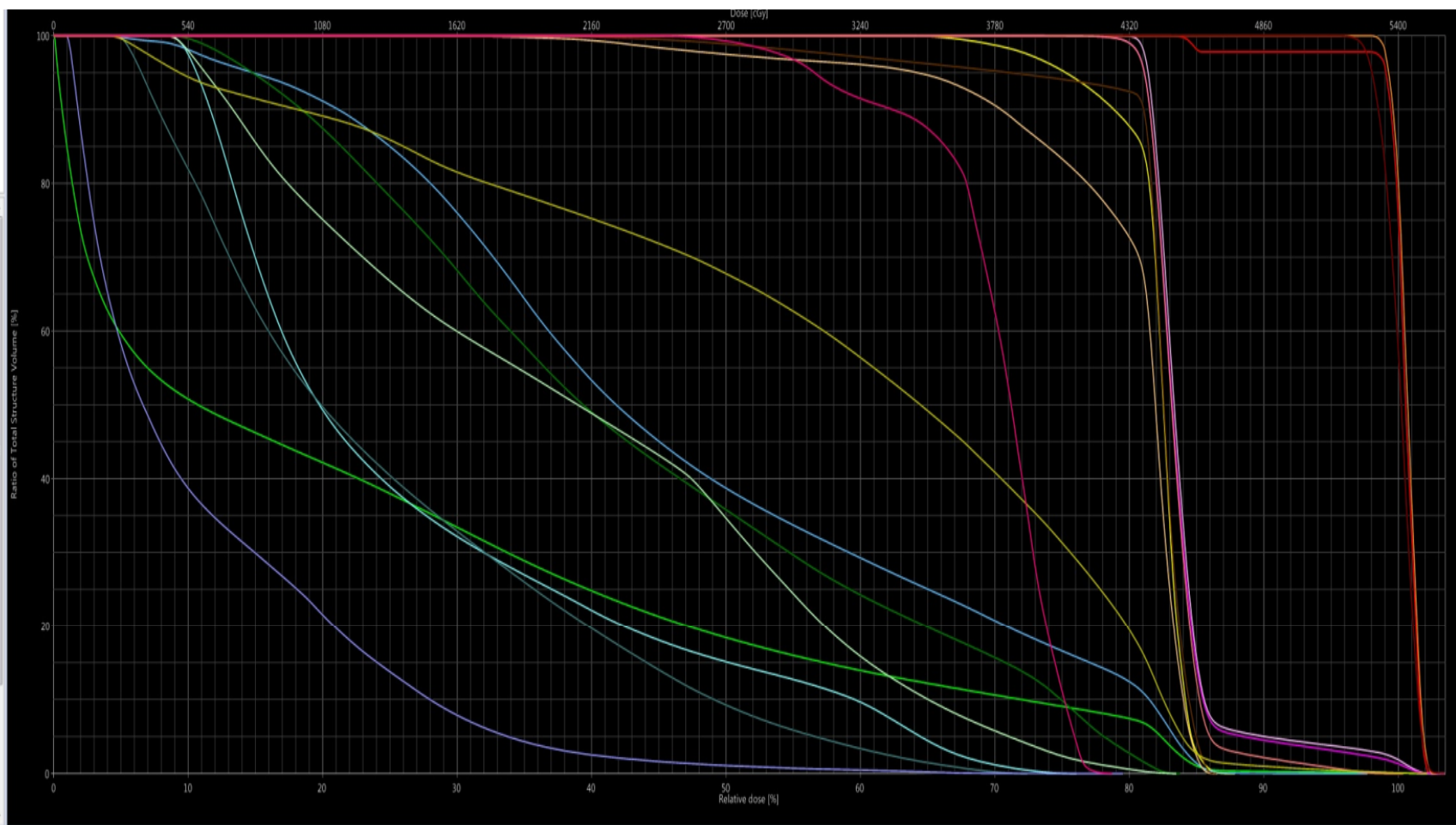
Plan2 - Treatment Approved - Sagittal - CT_1



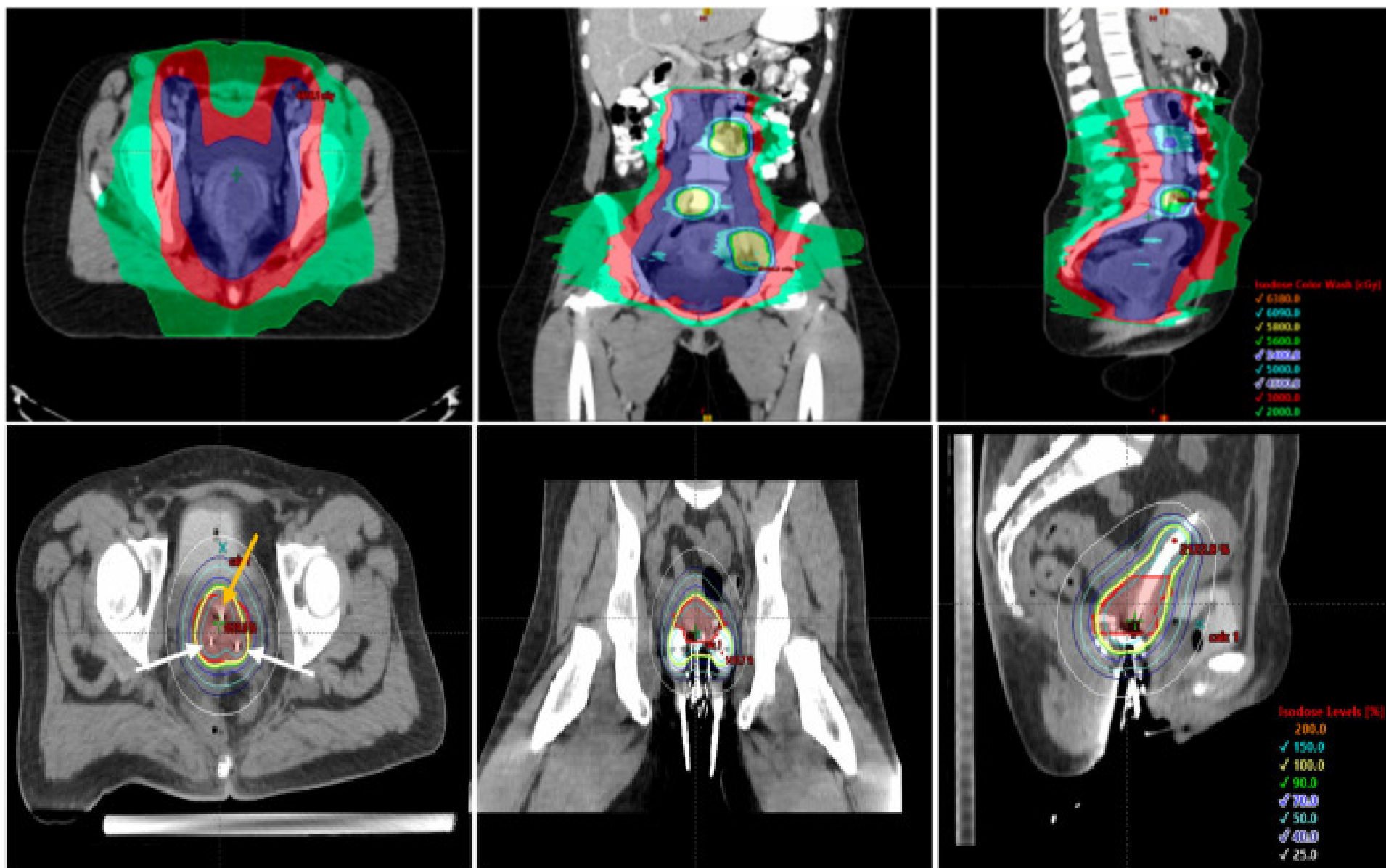
1
H₂ pelvis+pa+SIB : RO
Plan2

Plan2

- Registered Images
 - CT_1
 - bladder
 - BODY
 - Bone_Marrow
 - Bowel
 - CTV
 - CTV_LN
 - Femur_L
 - Femur_R
 - Kidney_L
 - Kidney_R
 - Igl
 - Liver
 - PTV 45
 - PTV 54
 - PTV45-54
 - Rectum
 - sigma
 - SpinalCord
- User Origin
- Reference Points
 - PTV45-54
- Dose
- Fields
 - Isocenter Group I
 - P0
 - P0-DRR (Live)
 - P270
 - P270-DRR (Live)



Show DVH	Structure	Approval Status	Plan	Course	Volume [cm ³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]	V50.0 [%]	V4750.0:cGy [%]
<input checked="" type="checkbox"/>	BODY	Approved	Plan2	1	39258.6	100.0	99.9	0.0	103.5	23.9	18.4	0.4
<input checked="" type="checkbox"/>	Kidney_R	Approved	Plan2	1	199.3	100.0	100.0	8.4	76.1	27.4	15.1	0.0
<input checked="" type="checkbox"/>	Kidney_L	Approved	Plan2	1	191.3	100.0	100.0	4.7	72.5	24.8	9.3	0.0
<input checked="" type="checkbox"/>	Bladder	Approved	Plan2	1	75.5	100.0	100.0	63.6	87.9	81.9	100.0	0.0
<input checked="" type="checkbox"/>	Igl	Approved	Plan2	1	8.9	100.0	100.2	83.0	102.4	100.2	100.0	97.8
<input checked="" type="checkbox"/>	Bowel	Approved	Plan2	1	1334.6	100.0	100.0	4.2	97.8	46.8	38.7	0.1
<input checked="" type="checkbox"/>	sigma	Approved	Plan2	1	159.2	100.0	100.0	29.7	86.6	79.1	97.5	0.0
<input checked="" type="checkbox"/>	Rectum	Approved	Plan2	1	91.2	100.0	100.0	33.7	86.5	81.4	98.9	0.0
<input checked="" type="checkbox"/>	Femur_L	Approved	Plan2	1	76.0	100.0	100.0	8.6	83.8	43.2	35.8	0.0
<input checked="" type="checkbox"/>	Femur_R	Approved	Plan2	1	81.9	100.0	100.0	8.3	83.5	38.8	34.6	0.0
<input checked="" type="checkbox"/>	Liver	Approved	Plan2	1	1519.3	100.0	99.8	0.8	79.5	11.5	1.1	0.0
<input checked="" type="checkbox"/>	CTV	Approved	Plan2	1	1587.8	100.0	100.0	78.6	103.5	84.1	100.0	5.7
<input checked="" type="checkbox"/>	PTV 45	Approved	Plan2	1	2467.3	100.0	100.0	69.2	103.5	83.8	100.0	5.2
<input checked="" type="checkbox"/>	CTV_LN	Approved	Plan2	1	20.2	100.0	100.1	97.9	102.8	100.7	100.0	100.0
<input checked="" type="checkbox"/>	PTV 54	Approved	Plan2	1	57.7	100.0	100.1	94.8	103.5	100.1	100.0	100.0
<input checked="" type="checkbox"/>	PTV45-54	Approved	Plan2	1	2407.9	100.0	100.0	69.2	100.4	83.4	100.0	2.9
<input checked="" type="checkbox"/>	Bone_Marrow	Approved	Plan2	1	1842.3	100.0	100.0	4.0	102.2	57.5	67.8	1.3
<input checked="" type="checkbox"/>	SpinalCord	Approved	Plan2	1	26.7	100.0	100.0	44.2	78.8	69.9	99.3	0.0

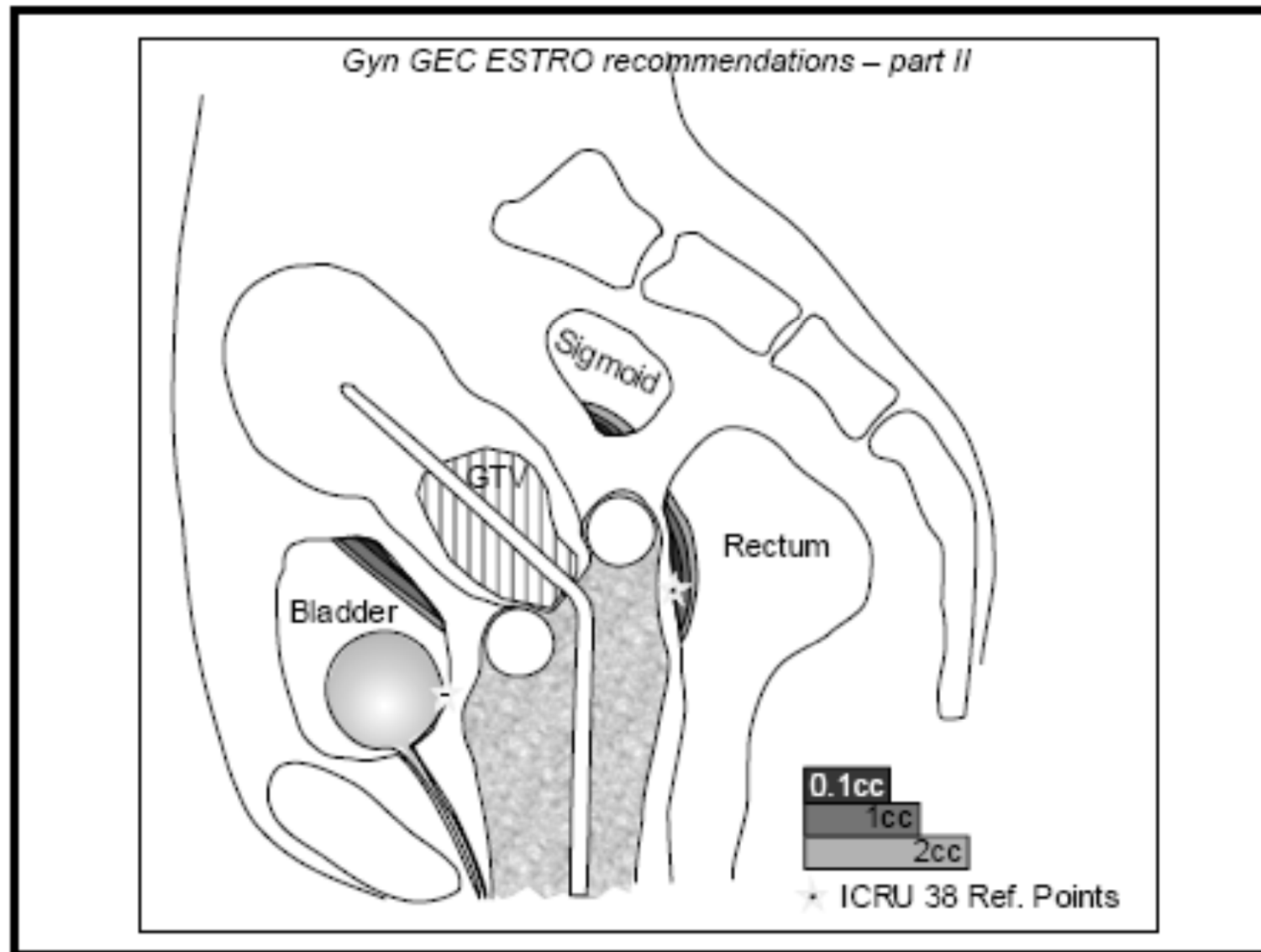


Williamson CW, et al. Advances in External Beam Radiation Therapy and Brachytherapy for Cervical Cancer. Clin Oncol (R Coll Radiol) 2021;33(9):567-78.

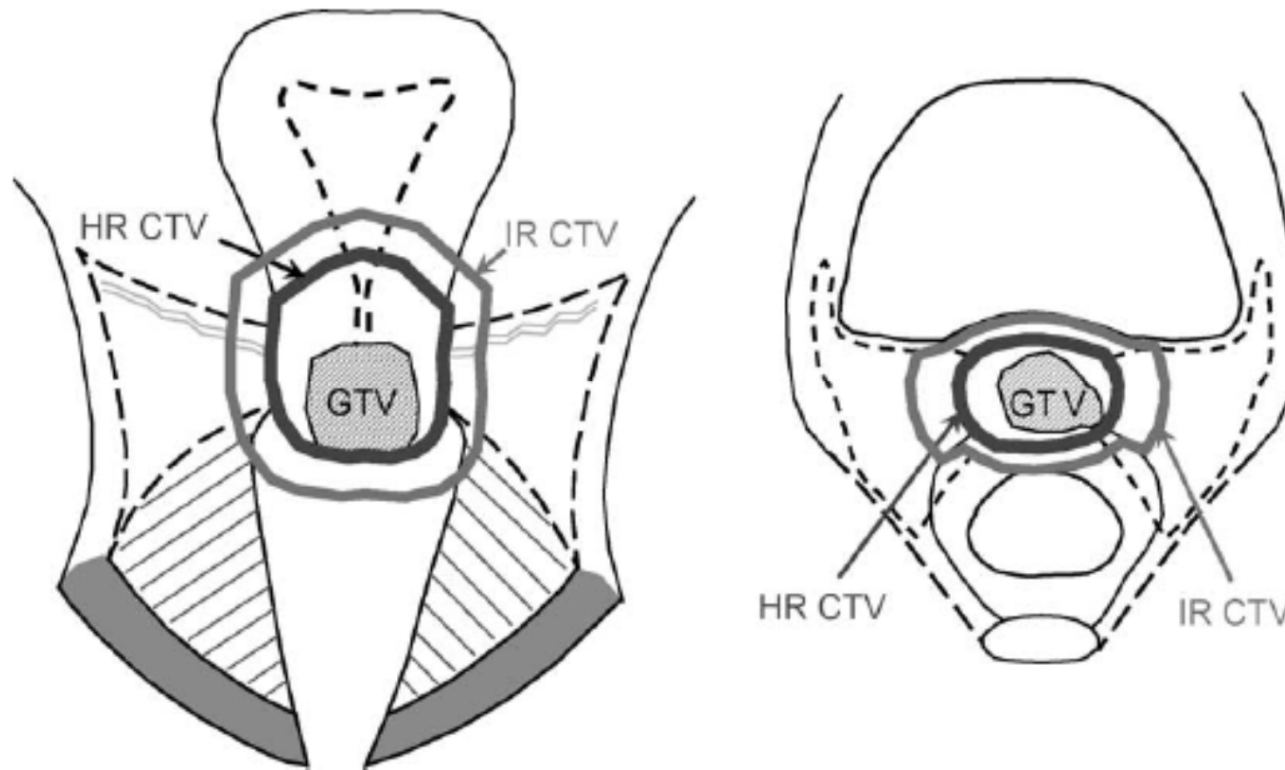
GEC-ESTRO BT recommendations

- **HR-CTV** - represents a region of high risk for local relapse due to the presence of microscopic disease
- **IR-CTV** - with a high risk for local relapse, in the regions of the initial macroscopic disease, which contains most of the microscopic disease at the time of brachytherapy
- **GTV** - changes during the treatment, according to which it is necessary that GTV and CTV are described and delineated during each brachytherapy application
- In order to save the organs from risk, delineation is performed, as well as the calculation of the dose to be delivered to the 2 cm² that are most exposed during the application of brachytherapy. The dose delivered during the brachytherapy application is added to the dose delivered by the EBRT technique according to the EQD2 model

Dose-volume tolerance values for organ at risk

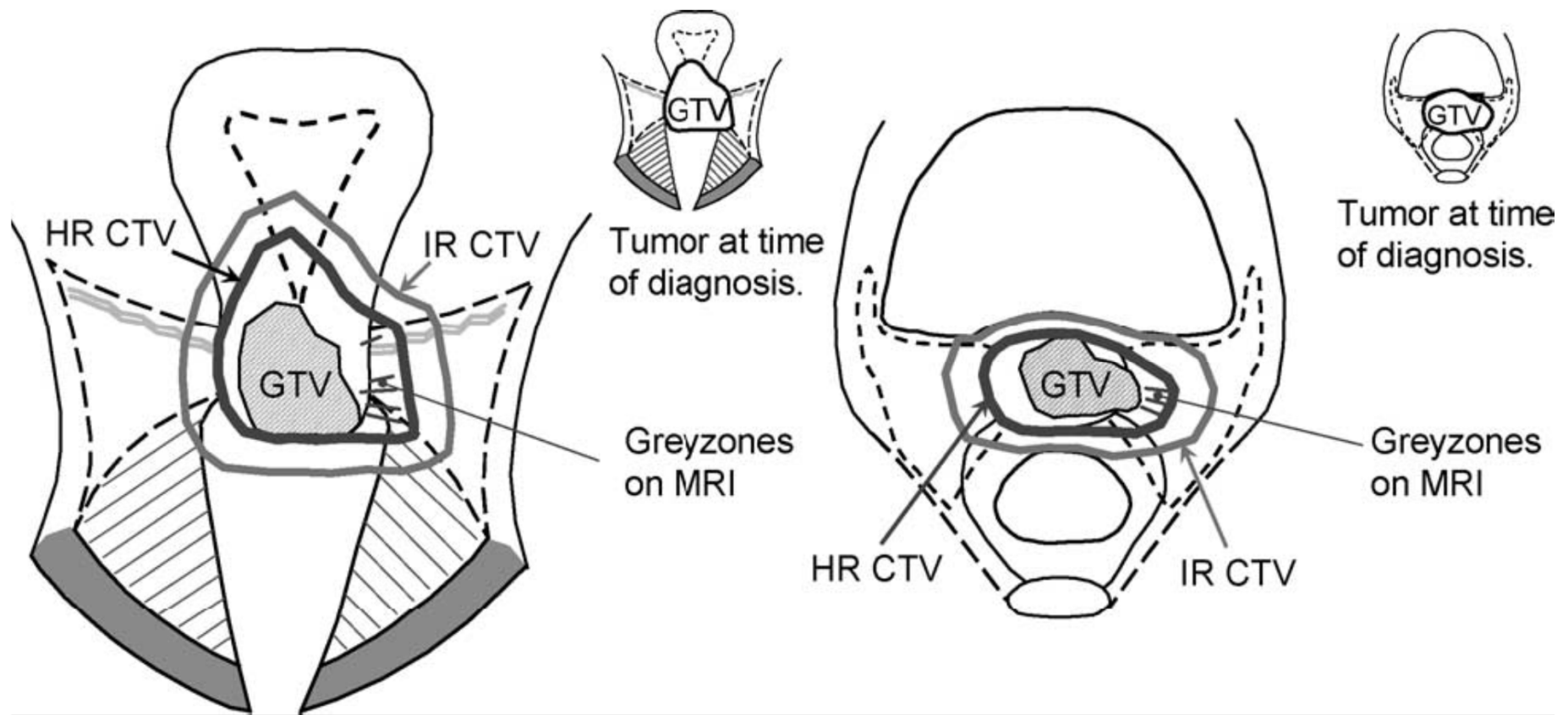


Target volumes

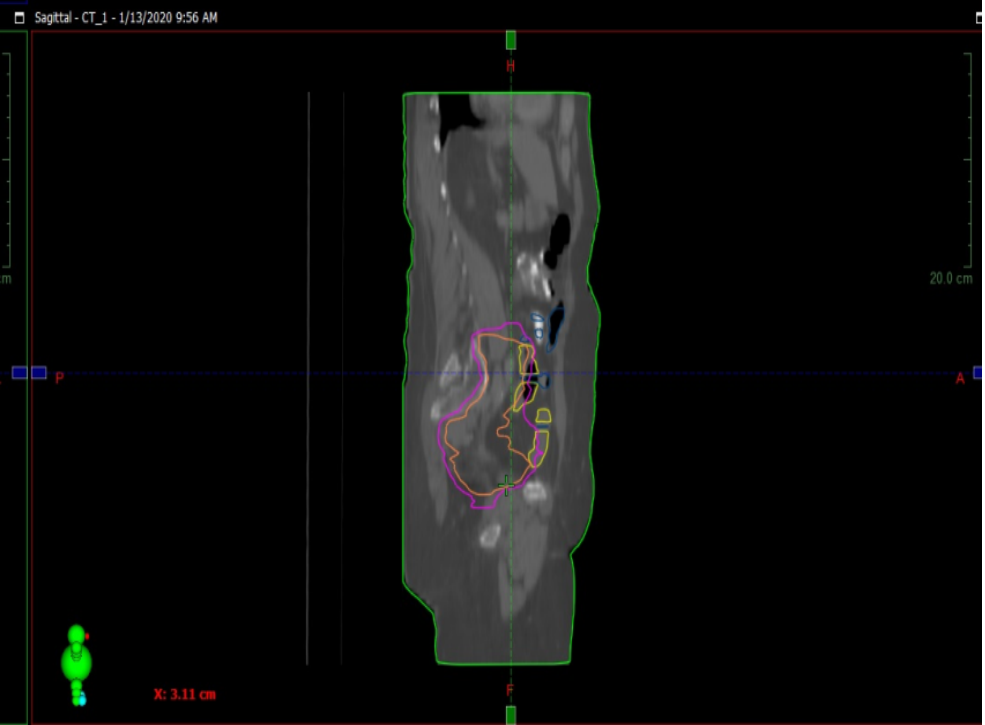
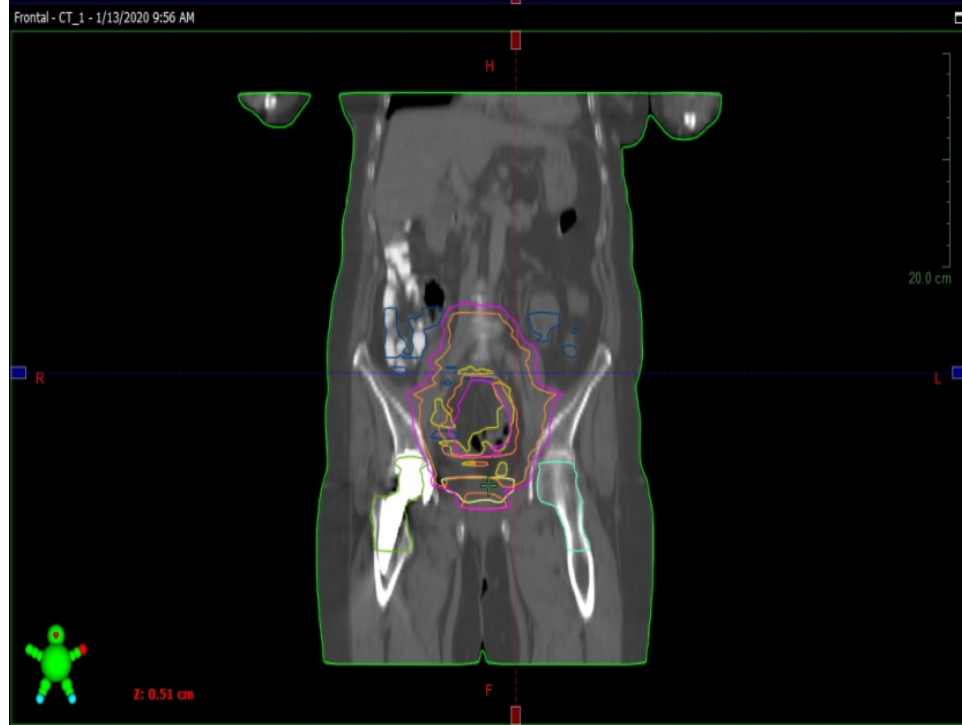
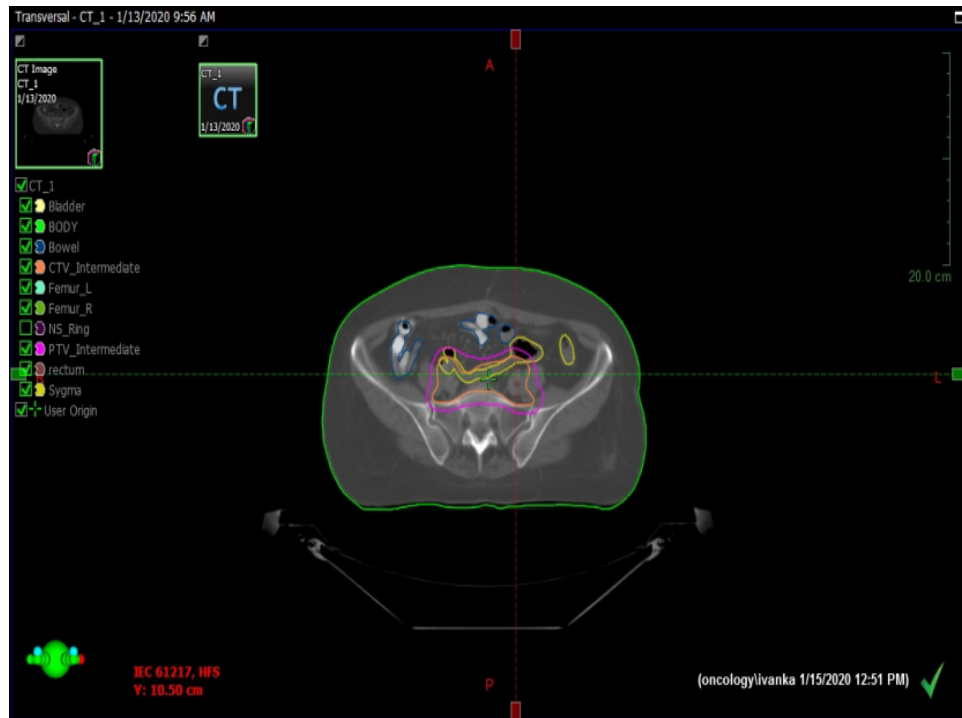


Schematic representation for cervical cancer, limited disease, with GTV, high risk CTV and intermediate risk CTV in radical radiation treatment: coronal and transverse view.

Target volumes



Schematic diagram for cervical cancer, advanced disease, weak remission after EBRT with GTV, and high risk CTV (grey zones on MRI) and intermediate risk CTV with radical radiation treatment (coronal and transverse sections).



The screenshot displays the Pinnacle 3.10a treatment planning interface. The main window shows a 3D dose distribution of the pelvis, with a red PTV and a yellow PTV_Intermediate. The 2D sagittal and coronal views show the same structures. The interface includes a left sidebar with a tree view of the plan, a top status bar, and a bottom table of dose statistics.

Left Sidebar (Tree View):

- Plan
 - Registered Images
 - CT_1
 - Bladder
 - BODY
 - Bowel
 - CTV_Intermediate
 - Femur_L
 - Femur_R
 - NS_Ring
 - PTV_Intermediate
 - rectum
 - Sigma
 - User Origin
 - Reference Points
 - PTV_Intermediate
 - Dose
 - Fields
 - Isocenter Group 1
 - P0
 - P0-DRR (Live)
 - P270
 - P270-DRR (Live)
 - Arc1
 - Arc1-DRR (Live)
 - MLC
 - Arc2
 - Arc2-DRR (Live)
 - MLC
 - Arc3
 - Arc3-DRR (Live)
 - MLC
 - Radiographs

Top Status Bar:

Color wash [%]
105.0
105.0
95.2
80.0
60.0
40.0
20.0
0.0

3D Dose MAX: 105.0 %
3D MAX for PTV_Intermediate: 105.0 %
3D MIN for PTV_Intermediate: 84.3 %
3D MEAN for PTV_Intermediate: 100.0 %

Plan - Treatment Approved - Frontal - CT_1
Plan - Treatment Approved - Sagittal - CT_1

Bottom Table (Dose Statistics):

Fields	Dose	Reference Points	Dose Statistics				
Show DVH	Structure	Approval Status	Plan				
<input checked="" type="checkbox"/>	BODY	Approved	1				
<input checked="" type="checkbox"/>	Bladder	Approved	1				
<input checked="" type="checkbox"/>	Femur_L	Approved	1				
<input checked="" type="checkbox"/>	Femur_R	Approved	1				
<input checked="" type="checkbox"/>	rectum	Approved	1				
<input checked="" type="checkbox"/>	Sigma	Approved	1				
<input checked="" type="checkbox"/>	Bowel	Approved	1				
<input checked="" type="checkbox"/>	CTV_Intermediate	Approved	1				
Volume [cm³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]	V50.0 [%]	V4750.0cGy [%]
39467.7	100.0	100.2	0.0	105.0	21.1	16.9	0.0
65.6	100.0	100.0	42.8	102.9	83.7	95.1	0.0
138.8	100.0	100.0	2.9	98.1	27.4	17.3	0.0
109.0	100.0	100.0	1.8	100.8	25.0	17.5	0.0
70.3	100.0	100.1	9.9	102.1	78.6	80.4	0.0
260.2	100.0	100.0	42.6	103.5	95.0	99.9	0.0
309.1	100.0	100.0	9.5	103.5	54.8	49.1	0.0
903.8	100.0	100.0	91.0	104.6	100.3	100.0	0.0

Postoperative radiotherapy of cervical cancer

4-6 weeks after surgery

- **Medium risk group:** after adequate surgery, parameters are negative, resection margins are negative, lymph nodes are negative
- **High-risk group +/-CHT potentiation:** positive resection margins, positive parameters, positive lymph nodes, inadequate type of surgery
- Pelvis:
 - medium risk group 40-45Gy, 1.8-2 Gy per fraction
 - high-risk group 45-50Gy, 1.8-2 Gy per fraction

Postoperative brachytherapy of cervical cancer

EBRT + Brachytherapy: 2-3 applications with a dose of 6 Gy per application, once a week

Brachytherapy 2-4x6 Gy

- EQD2 dose to the vaginal cuff region is 65-70Gy
- the dose is prescribed at 0.5 cm from the surface of the vaginal ovoids, i.e. the vaginal cylinder
- dose limits for organs at risk are determined in the ICRU reference points B_{\max} for the bladder and R_{\max} for the rectum according to ICRU-38 recommendations

FIGO classification of endometrial carcinoma (2023)

Stage	Description
Stage I	Confined to the uterine corpus and ovary ^c
IA	Disease limited to the endometrium OR non-aggressive histological type, i.e. low-grade endometrioid, with invasion of less than half of myometrium with no or focal lymphovascular space involvement (LVSI) OR good prognosis disease IA1 Non-aggressive histological type limited to an endometrial polyp OR confined to the endometrium IA2 Non-aggressive histological types involving less than half of the myometrium with no or focal LVSI IA3 Low-grade endometrioid carcinomas limited to the uterus and ovary ^c
IB	Non-aggressive histological types with invasion of half or more of the myometrium, and with no or focal LVSI ^d
IC	Aggressive histological types ^e limited to a polyp or confined to the endometrium
Stage II	Invasion of cervical stroma without extrauterine extension OR with substantial LVSI OR aggressive histological types with myometrial invasion
IIA	Invasion of the cervical stroma of non-aggressive histological types
IIB	Substantial LVSI ^d of non-aggressive histological types
IIC	Aggressive histological types ^e with any myometrial involvement
Stage III	Local and/or regional spread of the tumor of any histological subtype
IIIA	Invasion of uterine serosa, adnexa, or both by direct extension or metastasis IIIA1 Spread to ovary or fallopian tube (except when meeting stage IA3 criteria) ^c IIIA2 Involvement of uterine subserosa or spread through the uterine serosa
IIIB	Metastasis or direct spread to the vagina and/or to the parametria or pelvic peritoneum IIIB1 Metastasis or direct spread to the vagina and/or the parametria IIIB2 Metastasis to the pelvic peritoneum
IIIC	Metastasis to the pelvic or para-aortic lymph nodes or both ^f IIIC1 Metastasis to the pelvic lymph nodes IIIC1i Micrometastasis IIIC1ii Macrometastasis IIIC2 Metastasis to para-aortic lymph nodes up to the renal vessels, with or without metastasis to the pelvic lymph nodes IIIC2i Micrometastasis IIIC2ii Macrometastasis
Stage IV	Spread to the bladder mucosa and/or intestinal mucosa and/or distance metastasis
IVA	Invasion of the bladder mucosa and/or the intestinal/bowel mucosa
IVB	Abdominal peritoneal metastasis beyond the pelvis
IVC	Distant metastasis, including metastasis to any extra- or intra-abdominal lymph nodes above the renal vessels, lungs, liver, brain, or bone

Radical radiotherapy of endometrial cancer

- **Inoperable disease**
- **Contraindications for operative treatment**
- **Patient refuses surgery**

- **EBRT+Brachytherapy+/- CHT**
- Pelvis: 45-50Gy, 5 days/week, 1.8-2 Gy per fraction
- Para-aortic region: 45Gy, 5 days/week, 1.8 Gy per fraction
- Palliative doses: 30 Gy in 10 fractions, 20 Gy in 5 fractions
- Nodal boost:
- 55Gy pelvic lymphatics SIB – within 25 fractions / sequential to total dose
- 57.5 Gy para-aortic lymphatics SIB - within 25 fractions / sequential to total dose

Brachytherapy as part of radical radiotherapy for endometrial cancer

- 2D or 3D brachytherapy
- Intrauterine probe and ovoids
- TD 6-7 Gy in 4-6 fractions once a week
- Dose limits of organs of risk



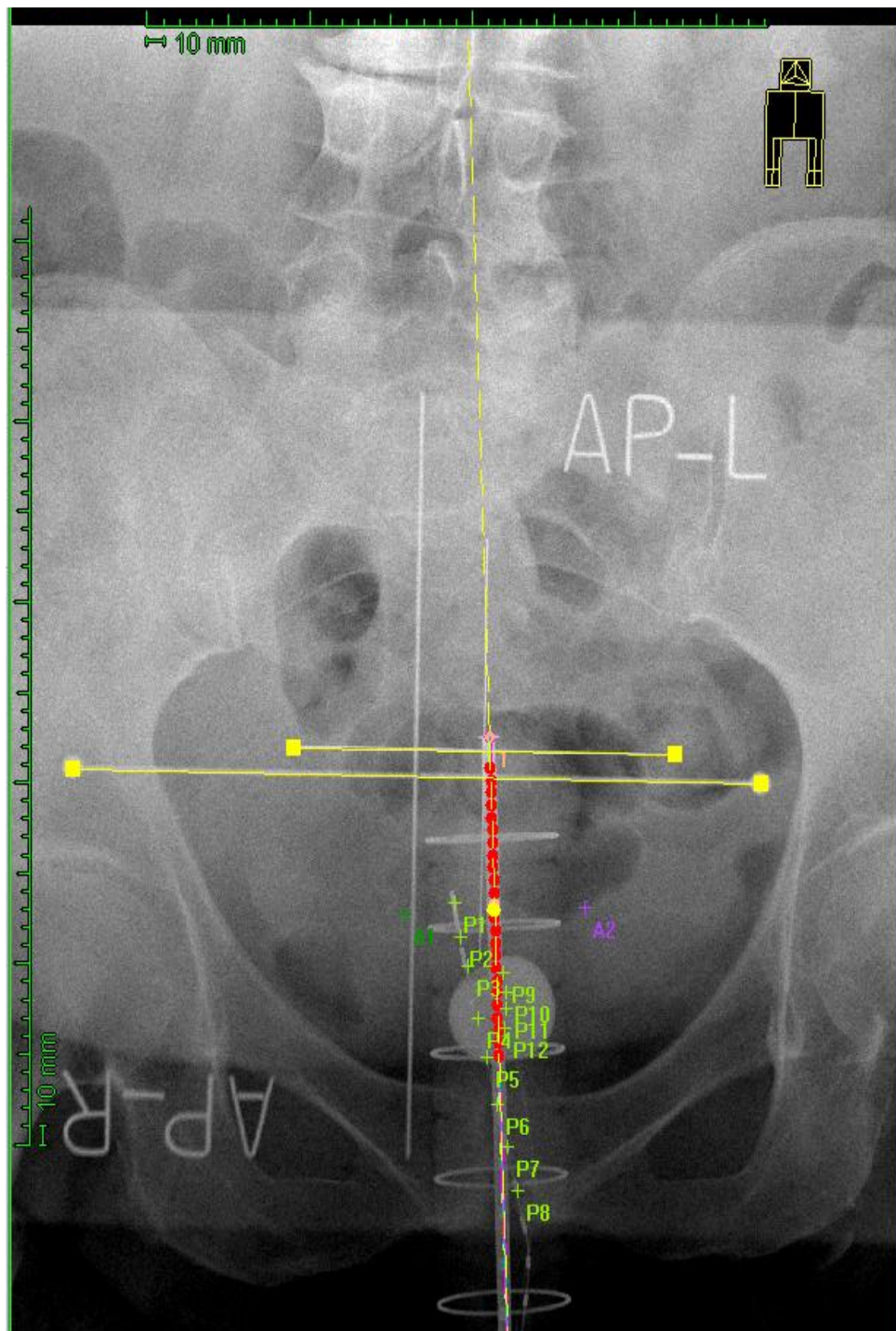
Schwarz JK, et al. Consensus statement for brachytherapy for the treatment of medically inoperable endometrial cancer. *Brachytherapy*. 2015;14(5):587-99.

Postoperative radiotherapy of endometrial cancer

- **Low-risk group:** endometrioid histology, G1/2, depth of infiltration $\leq 50\%$, LVI - **follow-up**
- **Intermediate risk group:** endometrioid histology, G1/2, infiltration depth $\geq 50\%$, LVI- **adjuvant brachytherapy (optional) or follow-up for patients over 60 years???**
- **Medium-high risk group:** endometrioid histology, G3, depth of infiltration $\geq 50\%$, regardless of LVI status, endometrioid histology, G1/2, LVI+, regardless of depth of infiltration - adjuvant RT (EBRT + BT) for unknown nodal status
- Adjuvant RT in G1/2 tumors, LVI+, node negative patients (G3??) - ESMO-ESTRO-ESGO recommendation for the whole group is adj BT if nodes are negative (at least 10 lgl, paraaortic??)
- **High-risk group:** endometrioid histology, G3, depth of infiltration $\geq 50\%$, regardless of LVI status - **adjuvant radiotherapy**
- FIGO stage II, endometrioid histology - adjuvant radiotherapy, adjuvant brachytherapy for G1/2, LVI- tumors, node negative
- FIGO stage III endometrioid histology, tumors of non-endometrioid histology (serous, clear-cell, undifferentiated, carcinosarcoma) - consider starting treatment with **adjuvant HT IV-VI cycles** (mandatory for FIGO IIIC1/2, FIGO III serous and clear-cell histologies, as well as for undifferentiated cancer and carcinosarcoma regardless of stage) + **sequential adjuvant radiotherapy**

Postoperative radiotherapy of endometrial cancer

- Pelvis: 40-50 Gy, 5 days/week, 1.8-2 Gy per fraction
- Para-aortic region: 45 Gy, 1.8 Gy per fraction
- Palliative doses: 30 Gy in 10 fractions, 20 Gy in 5 fractions
- Nodal boost:
- 55Gy pelvic lymphatics SIB – within 25 fractions / sequential to total dose
- 57.5Gy para-aortic lymphatics SIB - within 25 fractions / sequential to total dose
- Brachytherapy (2D or 3D)
- Vaginal cylinder
- TD 6-7 Gy in 3-4 fractions

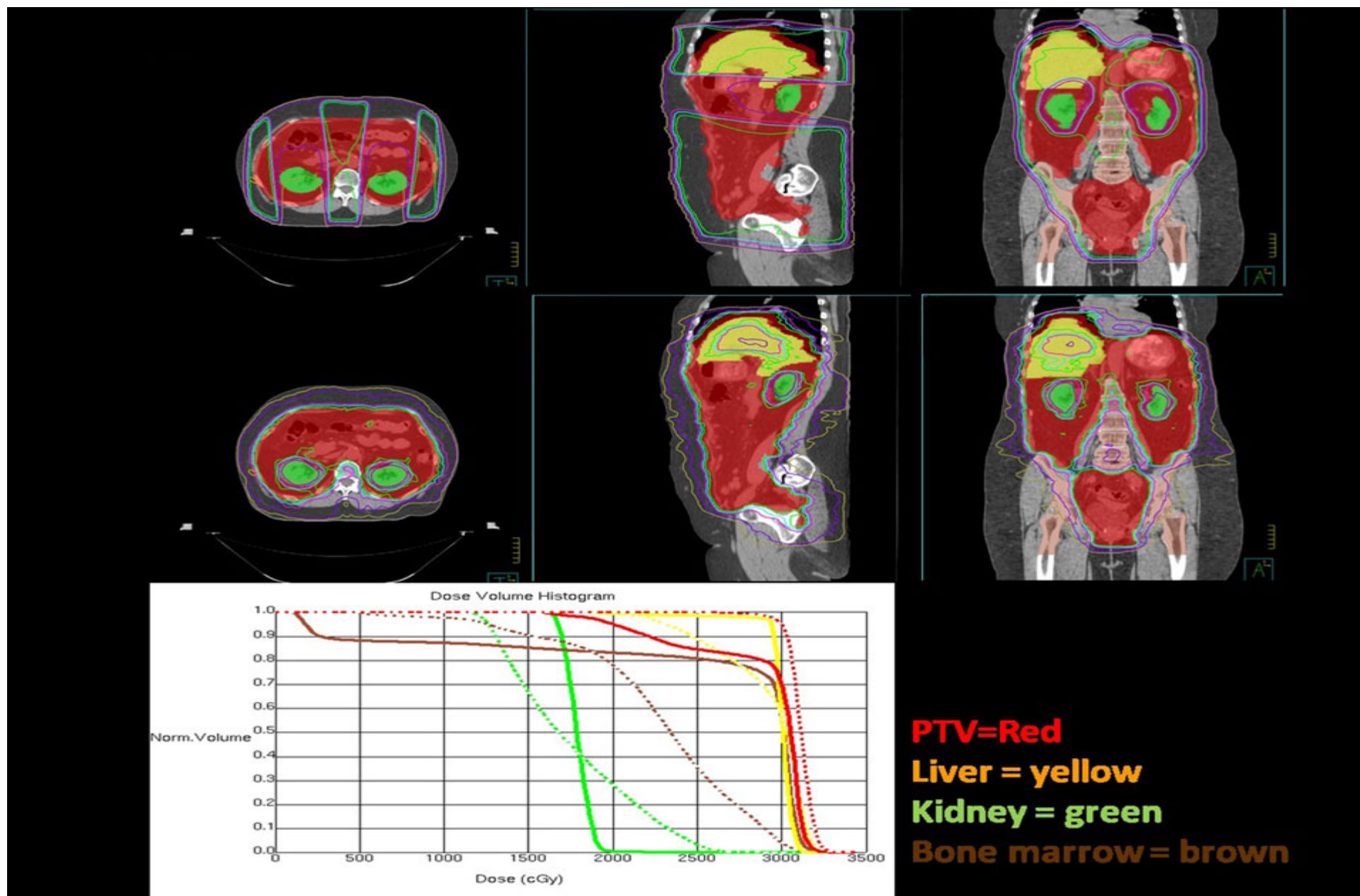


Ovarial cancer radiotherapy

- Not applicable by default
- Indicated in the adjuvant approach in locally advanced tumors (FIGO st. III) and/or the presence of residual disease

It is carried out in two phases:

- I Whole abdomen irradiation - TD 30 Gy/ 20 frakcija
- II Whole pelvis irradiation - total dose TD 45-50,4 Gy



Fields EC, et al. Radiation Treatment in Women with Ovarian Cancer: Past, Present, and Future. Front Oncol 2017;7:177.

Dose limits for organs at risk according to the QUANTEC study

Blader	Dmax < 105%
	V45Gy < 35%
	V40Gy < 60%
	V30Gy < 80%
Rectum	Dmax < 105%
	V40Gy < 75%
	V30Gy < 95%
Bowel	Dmax < 105%
	V40Gy < 30%
Duodenum (para-aortic)	prihvatljivo V45Gy < 30% ali V40Gy < 70%
	V55Gy < 15ccm
Bone marrow	Dmax < 50Gy
	V50Gy < 5%
	V40Gy < 35%
	V30Gy < 50%
Kidney	Dmean < 15Gy
	V28Gy < 20%
	V23Gy < 30%
	V20Gy < 32%
	V12Gy < 55%
Spinal cord	Dmax < 45Gy
Femoral head	Dmax < 50Gy
	V44Gy < 5%
	V30Gy < 20%
Transposed ovaries (optional)	Dmax < 5-8Gy

Digestive tract tumors radiotherapy



Slika: <https://cdhf.ca/en/digestive-conditions/colon-cancer/>

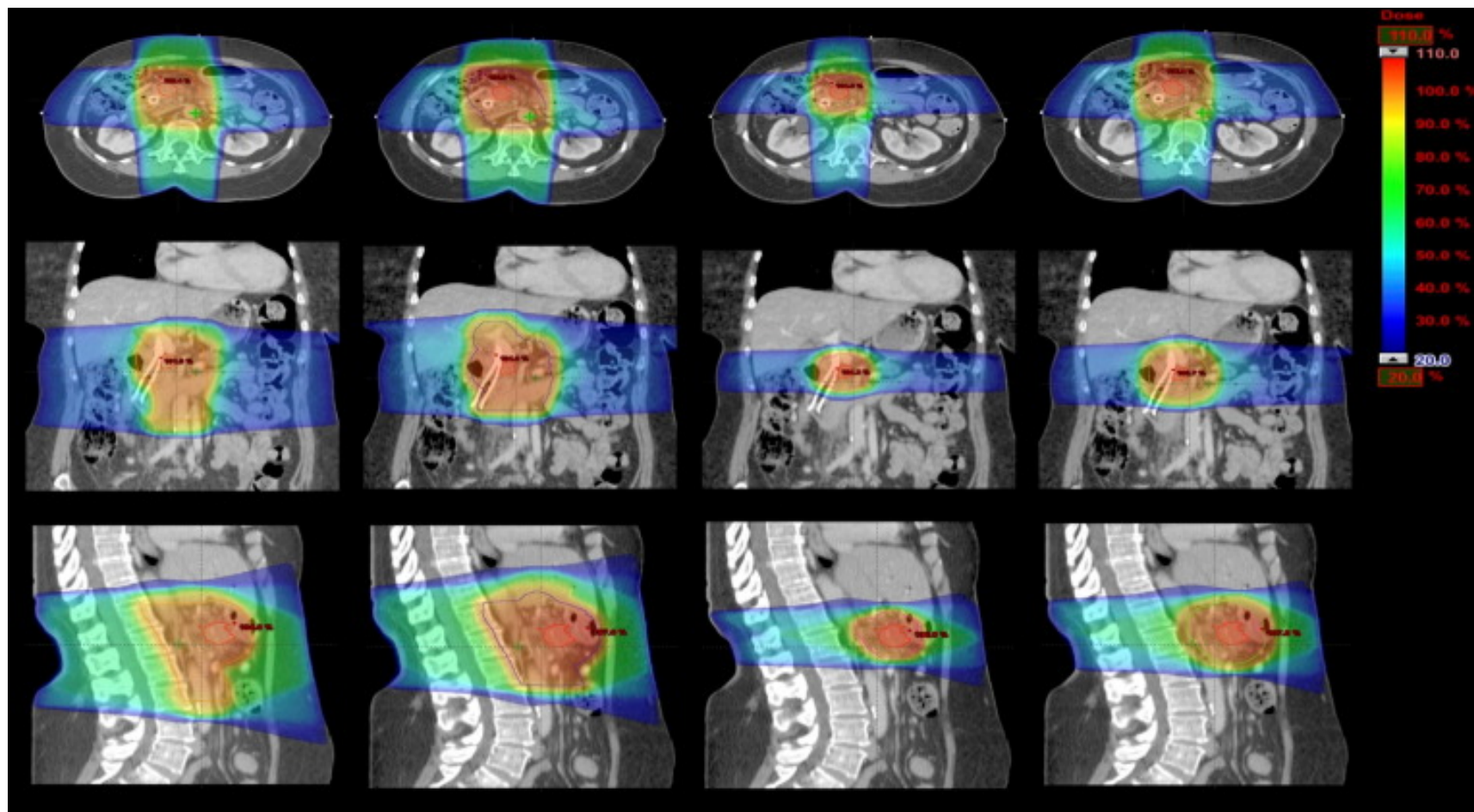
Pancreatic cancer radiotherapy

Preoperative or definitive RT +/- CHT

Adjuvant RT +/- CHT

- local recurrences rate reduction
- highly sophisticated RT techniques 45 Gy (daily dose 1.8 Gy)
- if the surgery is not satisfactory

Using the SBRT radiation technique, it is possible to apply a "boost" dose to the reduced target volume.



Fokas E, et al. A treatment planning comparison of four target volume contouring guidelines for locally advanced pancreatic cancer radiotherapy. *Radiother Oncol* 2013;107(2):200-6.

Hepatocellular carcinoma (HCC) radiotherapy

- Not applicable by default
- Highly sophisticated techniques
- SBRT shows promising results for the treatment of smaller primary tumor changes
- Precise application of a high therapeutic radiation dose (BED >100 Gy) to a respiratory mobile target volume in the liver

SBRT of liver metastases indications:

- up to 3 (metachronous) metastases
- not larger than 6 cm (best up to 3 cm)
- ECOG status 0-2
- CHT before and after SBRT

Esophageal carcinoma radiotherapy

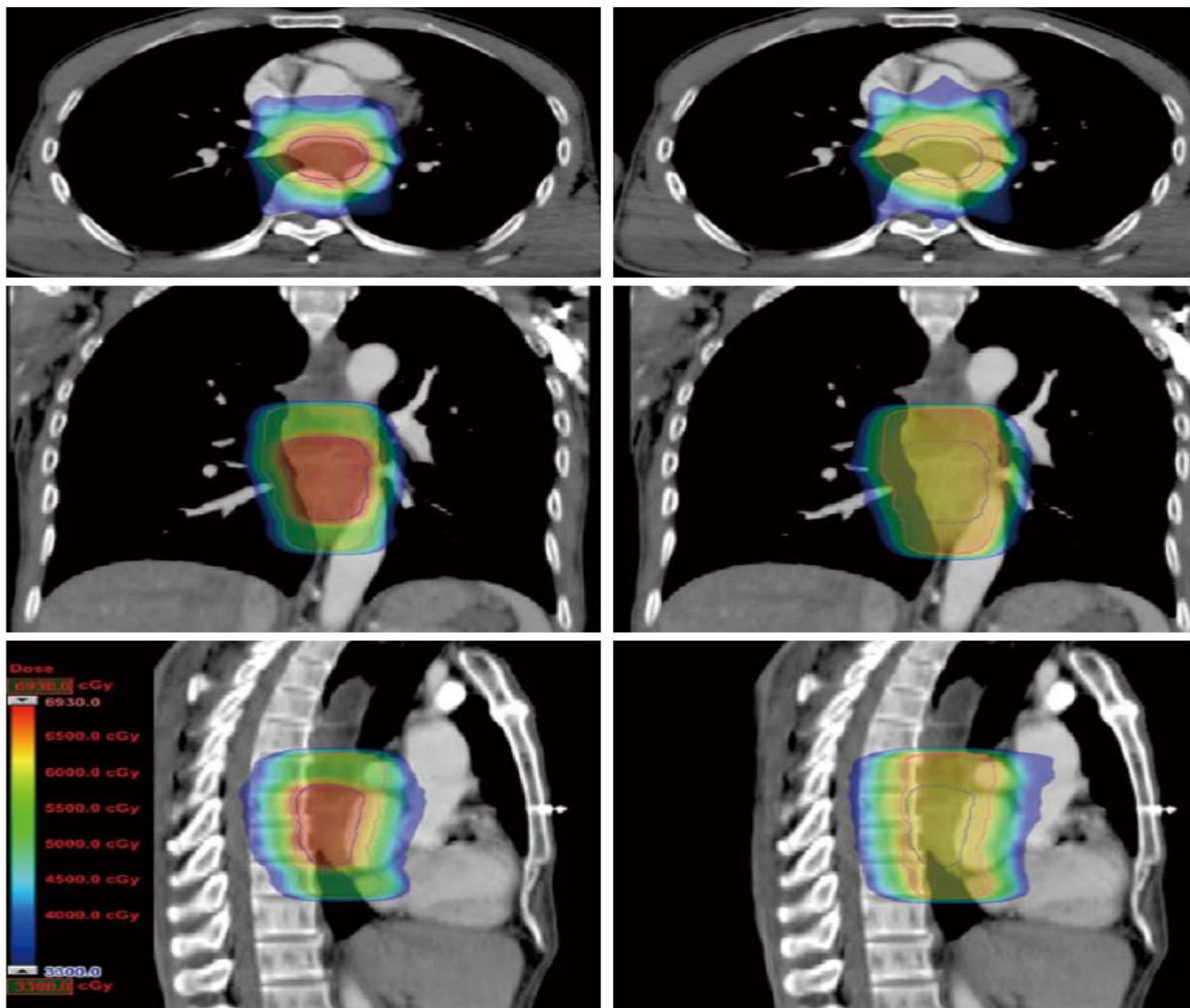
- **Neoadjuvant CHT-RT** (stages cT1b-T2N+; cT/cT and any cN+)
 - Phase I TD of 41.4 Gy applied in 23 fractions
 - Phase II TD 9 Gy in 5 fractions (only tumor and PET+ Ln)
- **Definitive CHT-RT** - cT4b stage (potentially curative approach in patients with SCC)
- **Palliative RT**

Recommendations for the treatment of squamous carcinoma (SCC) of the esophagus according to the stage

Stage 0 and Ia (T1a and T1b)	Esophagectomy Endoscopic mucosal resection or submucosal dissection with/without photodynamic therapy or radiofrequency ablation
Stage IB (T2-3N0), II and III (including patients with positive LN) – inoperables	The general approach for these stages is: preoperative chemotherapy (5-FU + cisplatin) + radiotherapy -> surgery
Stage IV - palliative therapy	Palliative chemotherapy Palliative chemoradiotherapy Palliative radiotherapy Palliative surgery Palliative symptomatic and supportive therapy.

Recommendations for the treatment of adenocarcinoma of the esophagus according to the stage

Stage 0 and Ia (T1a and T1b)	Esophagectomy Endoscopic mucosal resection or submucosal dissection with/without photodynamic therapy or radiofrequency ablation
Stage IB (T2-3N0), II and III (including patients with positive LN) – inoperable	Preoperative chemoradiotherapy (5-FU + cisplatin, 50 Gy), followed by diagnostics to assess operability
Stage III and IVA (operable), for patients with ECOG PS 0 or 1	Preoperative chemotherapy (5-FU + cisplatin) + radiotherapy - * surgery
Stage IV - palliative therapy	Cocurrent chemotherapy (5-FU + cisplatin) and radiotherapy Monotherapy such as: radiotherapy, chemotherapy Palliative surgery Palliative symptomatic, supportive and roborant therapy Placement of stents, dilators, endoscopic laser therapy



Zhang WZ, Chen JZ, Li DR, et al. Simultaneous modulated accelerated radiation therapy for esophageal cancer: a feasibility study. *World J Gastroenterol.* 2014;20(38):13973-80.

Brachytherapy of esophageal cancer

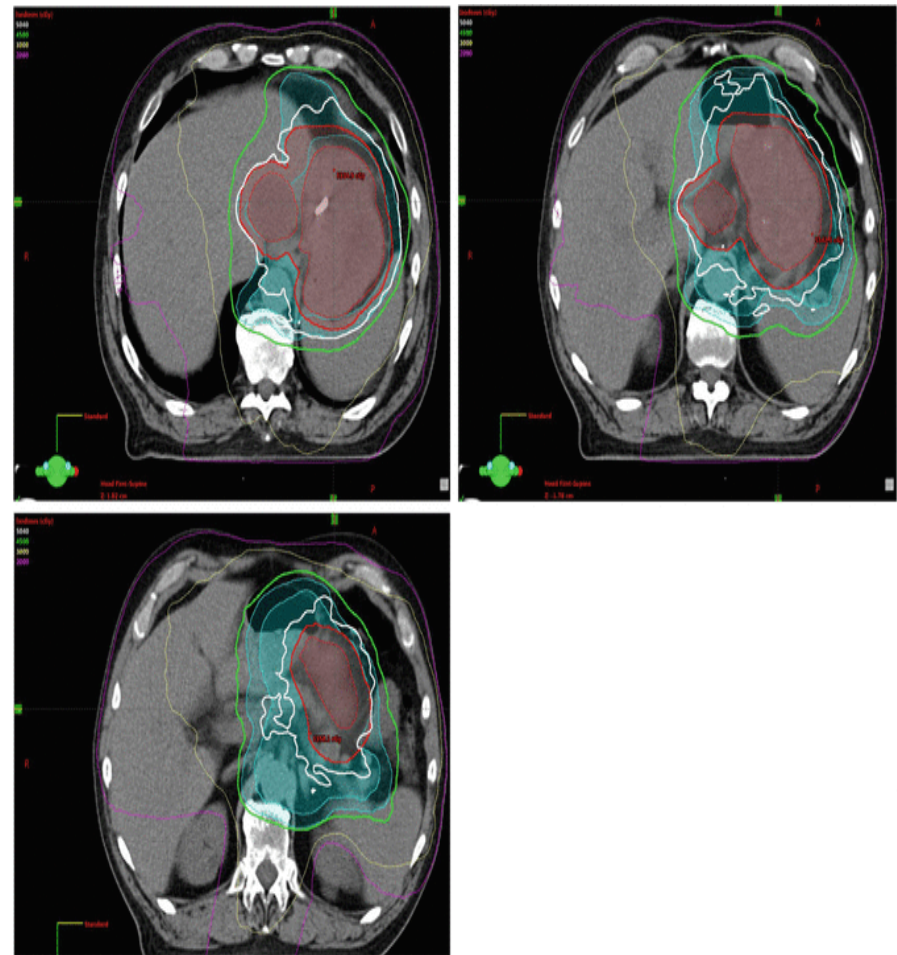
- Intraluminal, alone or in combination with laser ablation or EBRT
- The dose is prescribed at 1 cm lateral to the axis of the catheter
- Simple palliative regimens 1x 15Gy
- Local boost combined with EBRT 1 x 7.5 Gy at the beginning and end of EBRT
- Metastatic esophageal cancer with dysphagic complaints 1-2 x 6-10 Gy



Slika: <https://radiologykey.com/gastrointestinal-brachytherapy/>

Gastric cancer radiotherapy

- **RT combined with sequential and concomitant CHT** (Cisplatin/5-fluorouracil/leucovorin)
- **Preoperative RT** - 45 Gy in 25 fractions (tumors of the GEJ region, enables R0 resection)
- **Postoperative RT+/- CHT** - TD- 45 Gy in 25 fractions (stages II and III, suboptimal surgery, R1)
- **Metastatic disease** hypofractionated RT: symptomatic locally advanced or recurrent disease, bleeding, obstruction or pain



Hallemeier, C.L., Haddock, M.G. (2017). Gastric Cancer: Radiation Therapy Planning. In: Hong, T., Das, P. (eds) Radiation Therapy for Gastrointestinal Cancers. Springer, Cham. https://doi.org/10.1007/978-3-319-43115-4_6

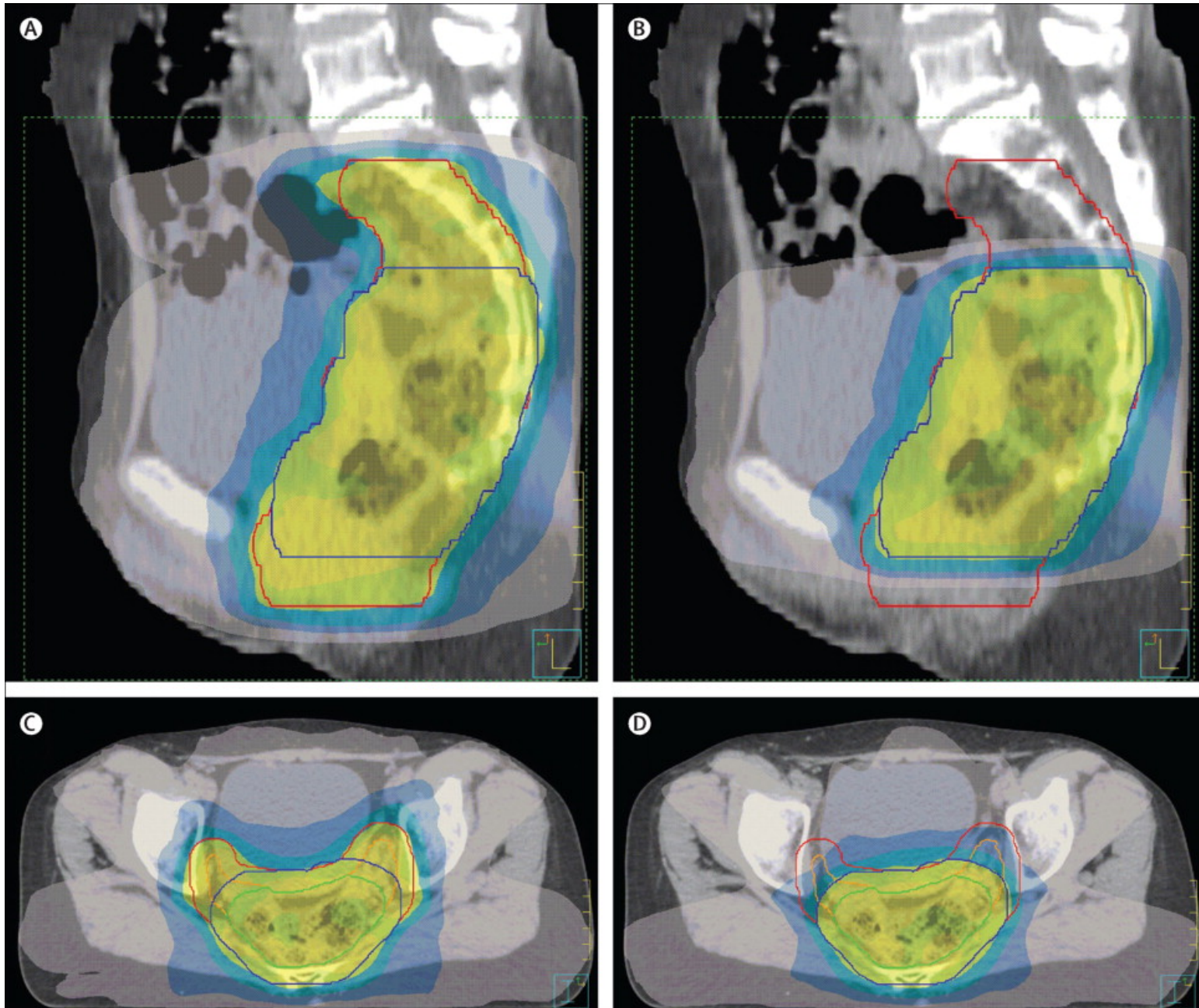
Radiotherapy of colon and rectal cancer

Neoadjuvant RT + CHT (5-Fu +/- oxaliplatin): stage II and III rectal cancer

- Primary aim: downsizing, downstaging, devitalization of tumor cells, increasing the efficiency of surgery, local disease control and long-term survival.
- Surgery follows 10-12 weeks after completion of RT
- In the case of complete response (CR), with frequent controls, the application of operative treatment can be delayed until a possible relapse of the disease (the so-called "watch and wait" approach)

Preoperative RT as monotherapy in a hypofractionated regimen, and surgery is performed within seven days of RT ("short course")

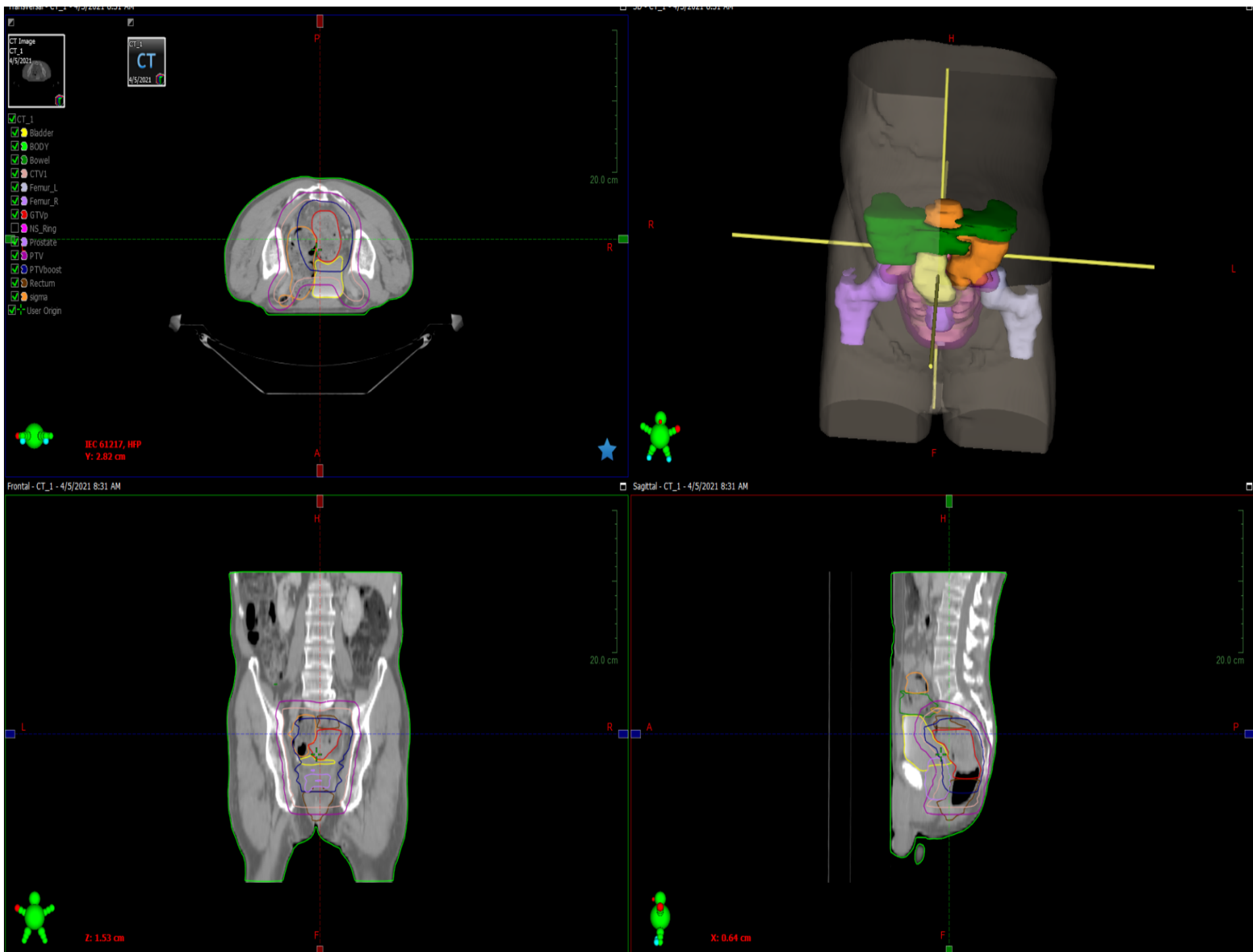
- Hypofractionated radiation (without chemotherapy), for the same PTV prescribes a dose of 25 Gy in 5 fractions.



Marijnen CA. Organ preservation in rectal cancer: have all questions been answered? *Lancet Oncol.* 2015 Jan;16(1):e13-22.

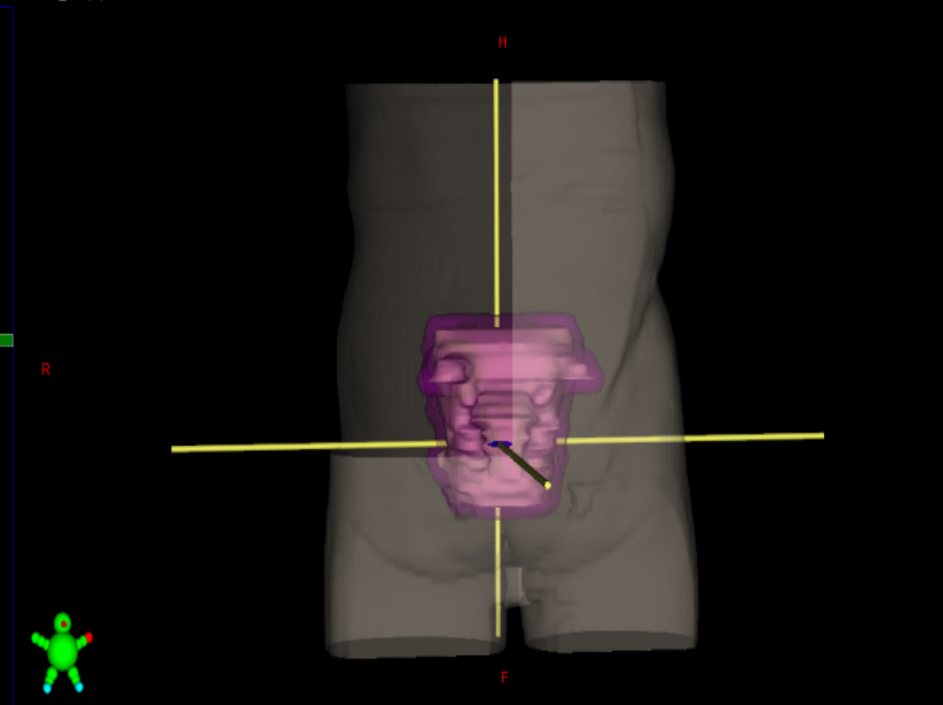
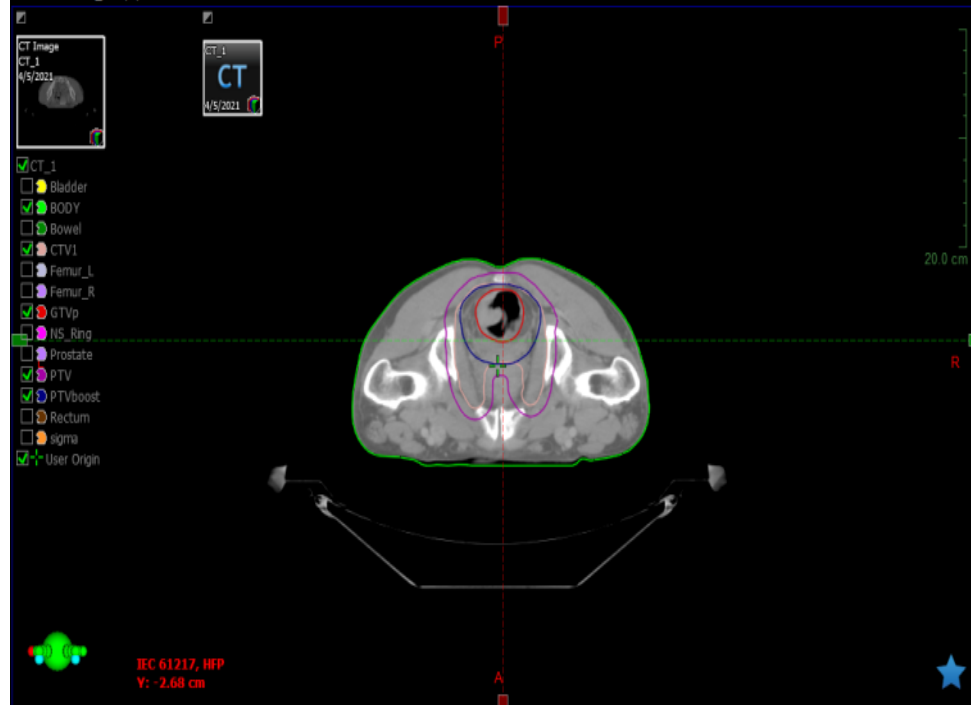
Radiotherapy of colon and rectal cancer

- **Adjuvant (postoperative) RT +/- CHT (5-Fu)** 4-6 weeks after surgery: pT3>pT4, pN+ stage, tumor infiltration of perirectal tissue and surrounding organs, resection margins <3 mm, tumor >3 cm, LVI positive LN or R1/2 resection in pT2N0 stage disease.
- Positive resection margins (R1) after performed preoperative HT-RT and operative treatment - consider postoperative application of a boost dose to the tumor bed of 25 Gy in 5 fractions using the SBRT technique, before performing adjuvant HT



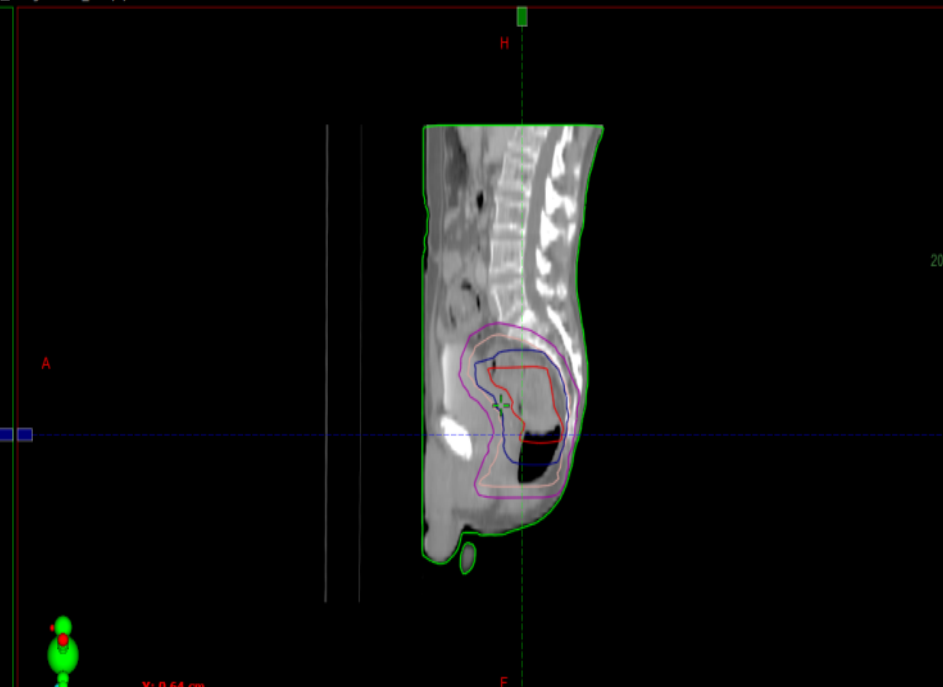
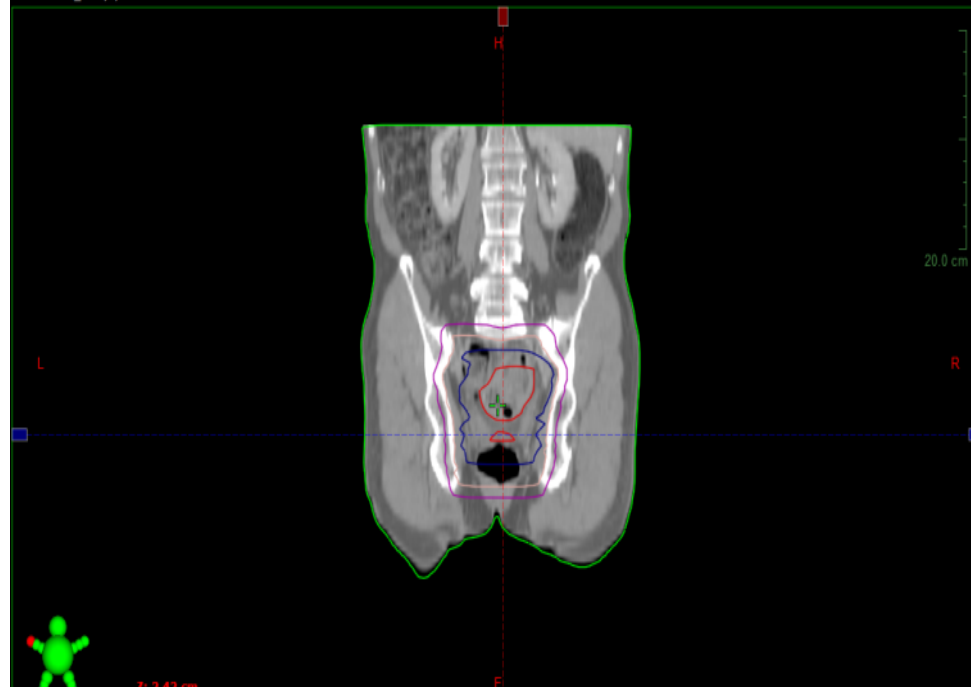
Transversal - CT_1 - 4/5/2021 8:31 AM

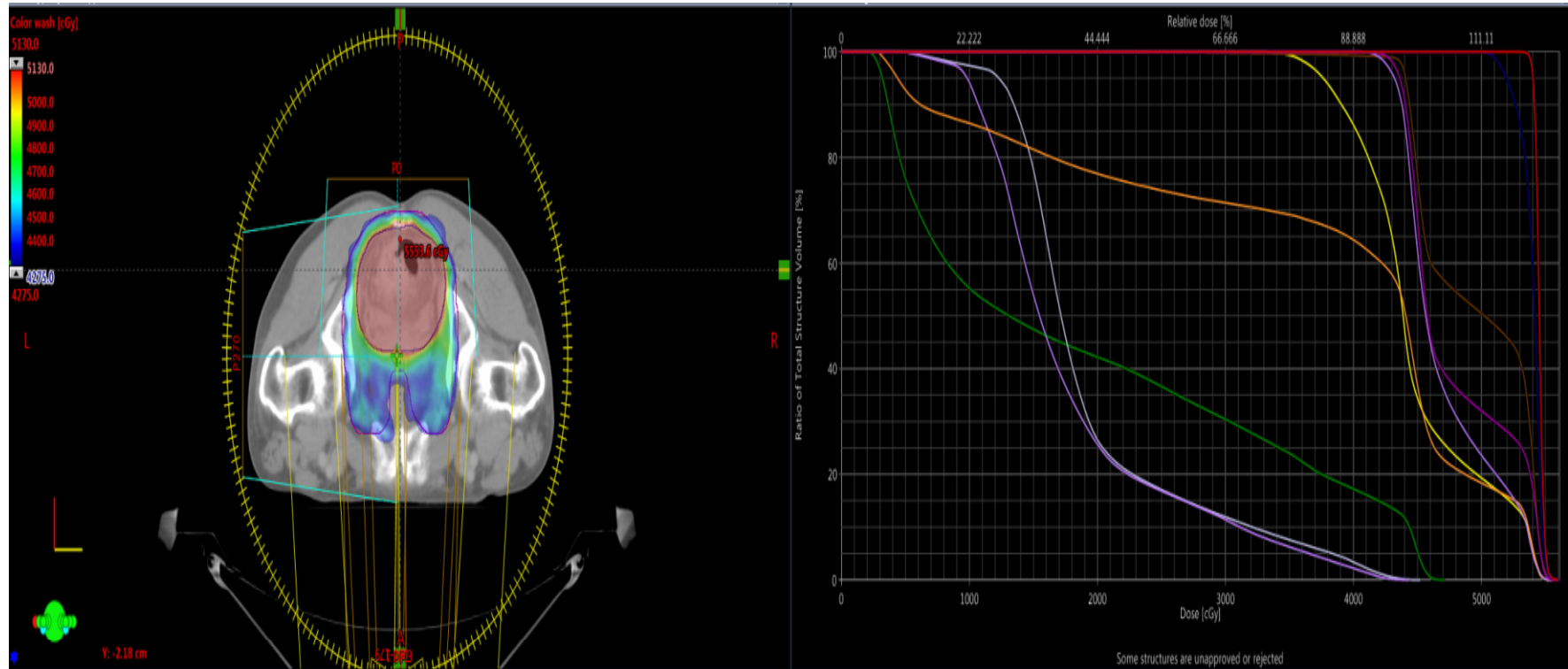
3D - CT_1 - 4/5/2021 8:31 AM



Frontal - CT_1 - 4/5/2021 8:31 AM

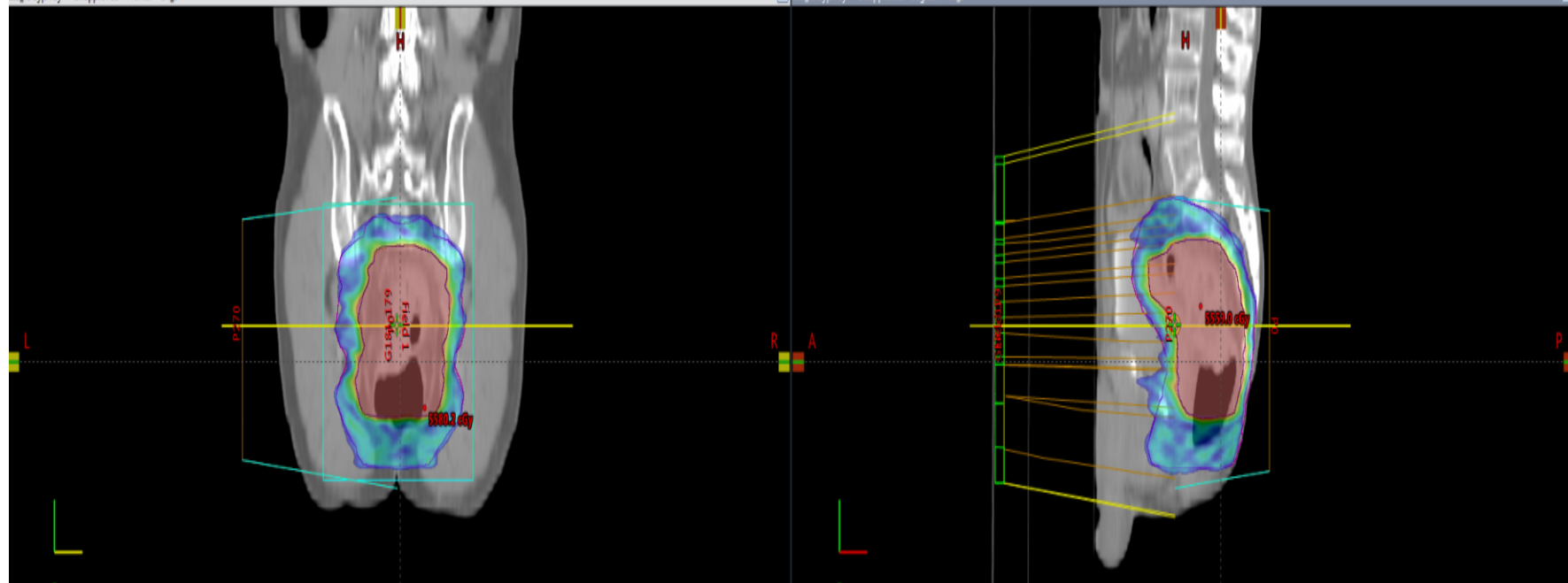
Sagittal - CT_1 - 4/5/2021 8:31 AM

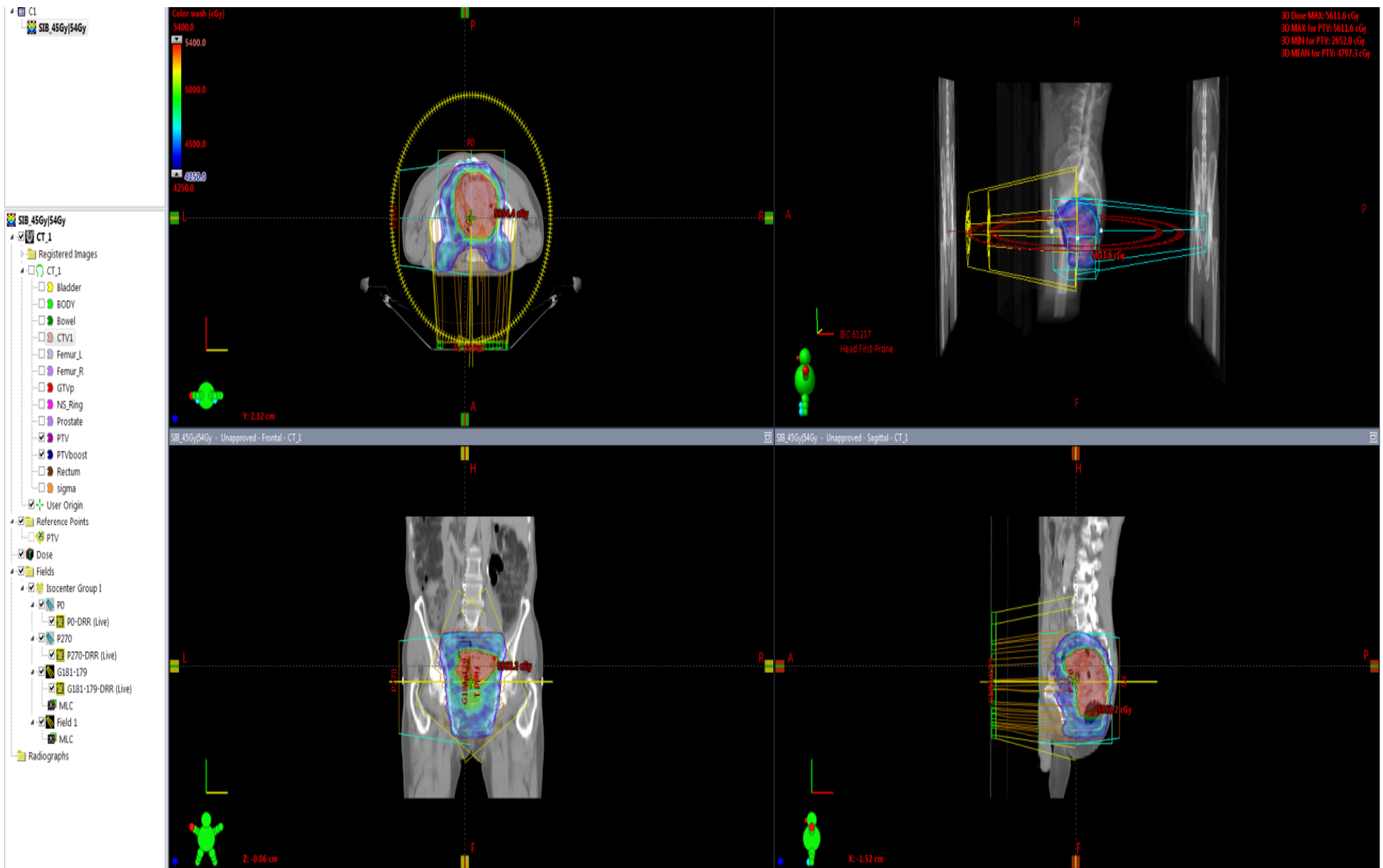




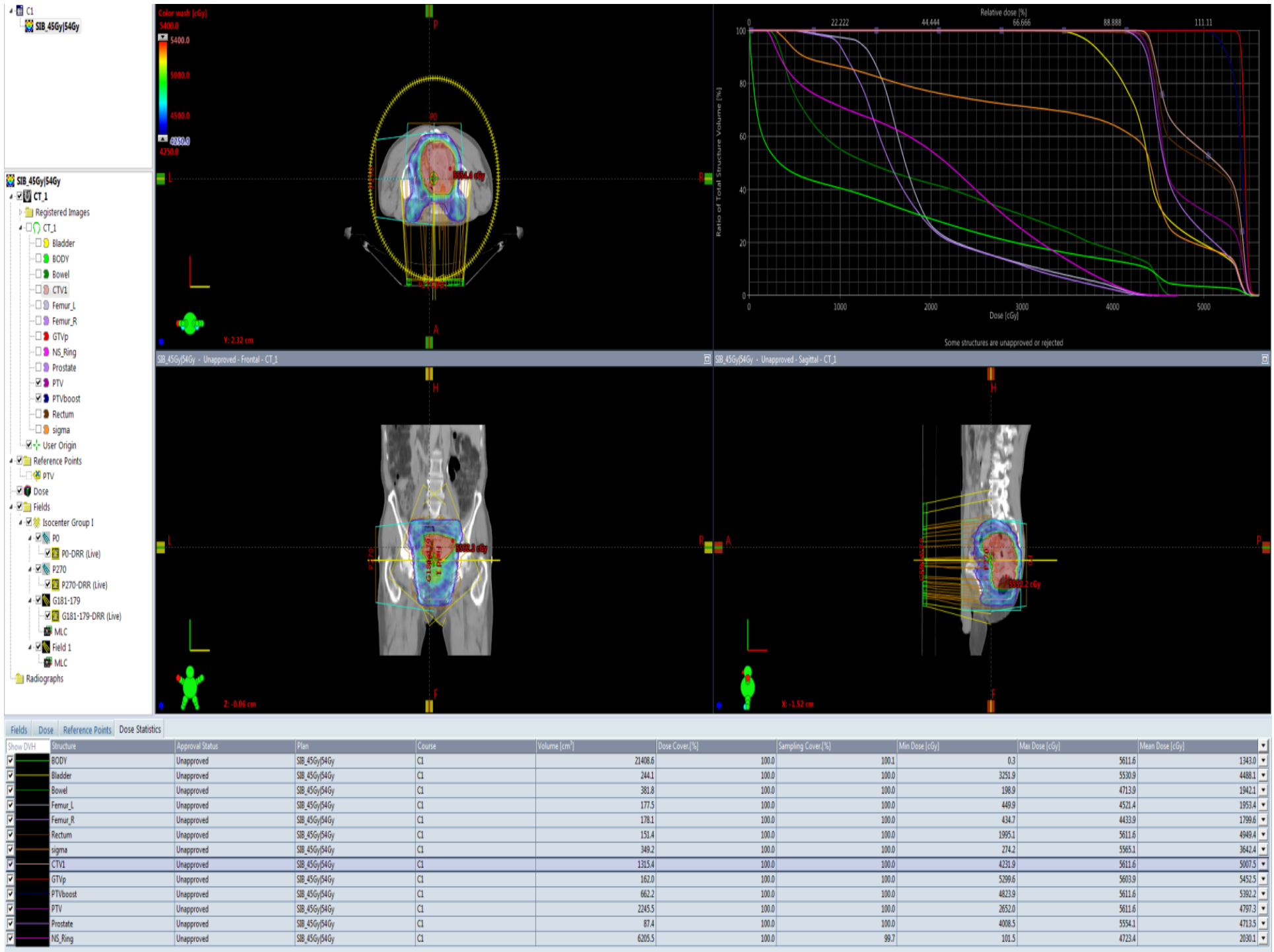
SIB_45Gy/54Gy - Unapproved - Frontal - CT_1

SIB_45Gy/54Gy - Unapproved - Sagittal - CT_1





Fields	Dose	Reference Points	Dose Statistics							
Show DVH	Structure	Approval Status	Plan	Course	Volume [cm ³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [cGy]	Max Dose [cGy]	Mean Dose [cGy]
<input checked="" type="checkbox"/>	BODY	Unapproved	SB_45Gy/54Gy	C1	21408.6	100.0	100.0	0.3	5611.6	1343.0
<input checked="" type="checkbox"/>	Bladder	Unapproved	SB_45Gy/54Gy	C1	244.1	100.0	100.0	3251.9	5530.9	4488.1
<input checked="" type="checkbox"/>	Bowel	Unapproved	SB_45Gy/54Gy	C1	381.8	100.0	100.0	198.9	4713.9	1942.1
<input checked="" type="checkbox"/>	Femur_L	Unapproved	SB_45Gy/54Gy	C1	177.5	100.0	100.0	449.9	4521.4	1953.4
<input checked="" type="checkbox"/>	Femur_R	Unapproved	SB_45Gy/54Gy	C1	178.1	100.0	100.0	434.7	4433.9	1799.6
<input checked="" type="checkbox"/>	Rectum	Unapproved	SB_45Gy/54Gy	C1	151.4	100.0	100.0	1995.1	5611.6	4949.4
<input checked="" type="checkbox"/>	Sigma	Unapproved	SB_45Gy/54Gy	C1	349.2	100.0	100.0	274.2	5565.1	3642.4
<input checked="" type="checkbox"/>	CTV1	Unapproved	SB_45Gy/54Gy	C1	1315.4	100.0	100.0	4231.9	5611.6	5007.5



C1

SIB_45Gy[54Gy]

SIB_45Gy[54Gy]

CT_1

Registered Images

CT_1

Bladder
BODY
Bowel
CTV1
Femur_L
Femur_R
GTVp
NS_Ring
Prostate
PTV
PTVboost
Rectum
sigma
User Origin

Reference Points

PTV
Dose
Fields

Isocenter Group 1

P0

P0-DRR (Live)
P270

P270-DRR (Live)
G181-179

G181-179-DRR (Live)
MLC
Field 1
MLC
Radiographs

Relative dose [%]

Ratio of Total Structure Volume [%]

Dose [Gy]

Some structures are unapproved or rejected

Show DVH	Structure	Approval Status	Plan	Course	Volume [cm ³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [Gy]	Max Dose [Gy]	Mean Dose [Gy]	
<input checked="" type="checkbox"/>	BODY	Unapproved	SIB_45Gy[54Gy]	C1	21408.6	21408.6	100.0	100.1	0.3	5611.6	1343.0
<input checked="" type="checkbox"/>	Bladder	Unapproved	SIB_45Gy[54Gy]	C1	244.1	244.1	100.0	100.0	3251.9	5530.9	4488.1
<input checked="" type="checkbox"/>	Bowel	Unapproved	SIB_45Gy[54Gy]	C1	381.8	381.8	100.0	100.0	198.9	4713.9	1942.1
<input checked="" type="checkbox"/>	Femur_L	Unapproved	SIB_45Gy[54Gy]	C1	177.5	177.5	100.0	100.0	449.9	4521.4	1953.4
<input checked="" type="checkbox"/>	Femur_R	Unapproved	SIB_45Gy[54Gy]	C1	178.1	178.1	100.0	100.0	434.7	4433.9	1799.6
<input checked="" type="checkbox"/>	Rectum	Unapproved	SIB_45Gy[54Gy]	C1	151.4	151.4	100.0	100.0	1995.1	5611.6	4949.4
<input checked="" type="checkbox"/>	sigma	Unapproved	SIB_45Gy[54Gy]	C1	349.2	349.2	100.0	100.0	274.2	5565.1	3642.4
<input checked="" type="checkbox"/>	CTV1	Unapproved	SIB_45Gy[54Gy]	C1	1315.4	1315.4	100.0	100.0	4231.9	5611.6	5007.5
<input checked="" type="checkbox"/>	GTVp	Unapproved	SIB_45Gy[54Gy]	C1	162.0	162.0	100.0	100.0	5299.6	5603.9	5452.5
<input checked="" type="checkbox"/>	PTVboost	Unapproved	SIB_45Gy[54Gy]	C1	662.2	662.2	100.0	100.0	4823.9	5611.6	5392.2
<input checked="" type="checkbox"/>	PTV	Unapproved	SIB_45Gy[54Gy]	C1	2245.5	2245.5	100.0	100.0	2652.0	5611.6	4797.3
<input checked="" type="checkbox"/>	Prostate	Unapproved	SIB_45Gy[54Gy]	C1	87.4	87.4	100.0	100.0	4008.5	5554.1	4713.5
<input checked="" type="checkbox"/>	NS_Ring	Unapproved	SIB_45Gy[54Gy]	C1	6205.5	6205.5	100.0	99.7	101.5	4723.4	2030.1

Ready

User: Luka Jovanovic

Group: Radiation Oncologist

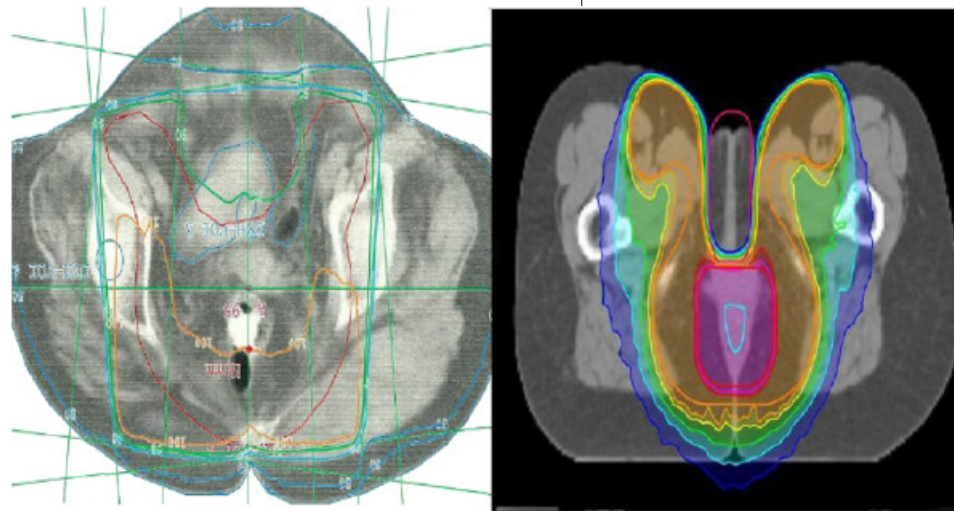
Site: Main

CAP: NUM

SCRU

Anal cancer radiotherapy

- EBRT or brachytherapy
- **Neoadjuvant to competitive EBRT and CHT**
- The original "**Nigro regimen**" of this therapy includes chemotherapy in the first and fifth weeks with continuous radiotherapy.
- D1-D5 for 5 weeks: 5-Fu 1000 mg/m²/day by continuous i.v. infusion
D1-D4 and D29-D32 + Mitomycin 10 mg/m² i.v. D1 and D29.

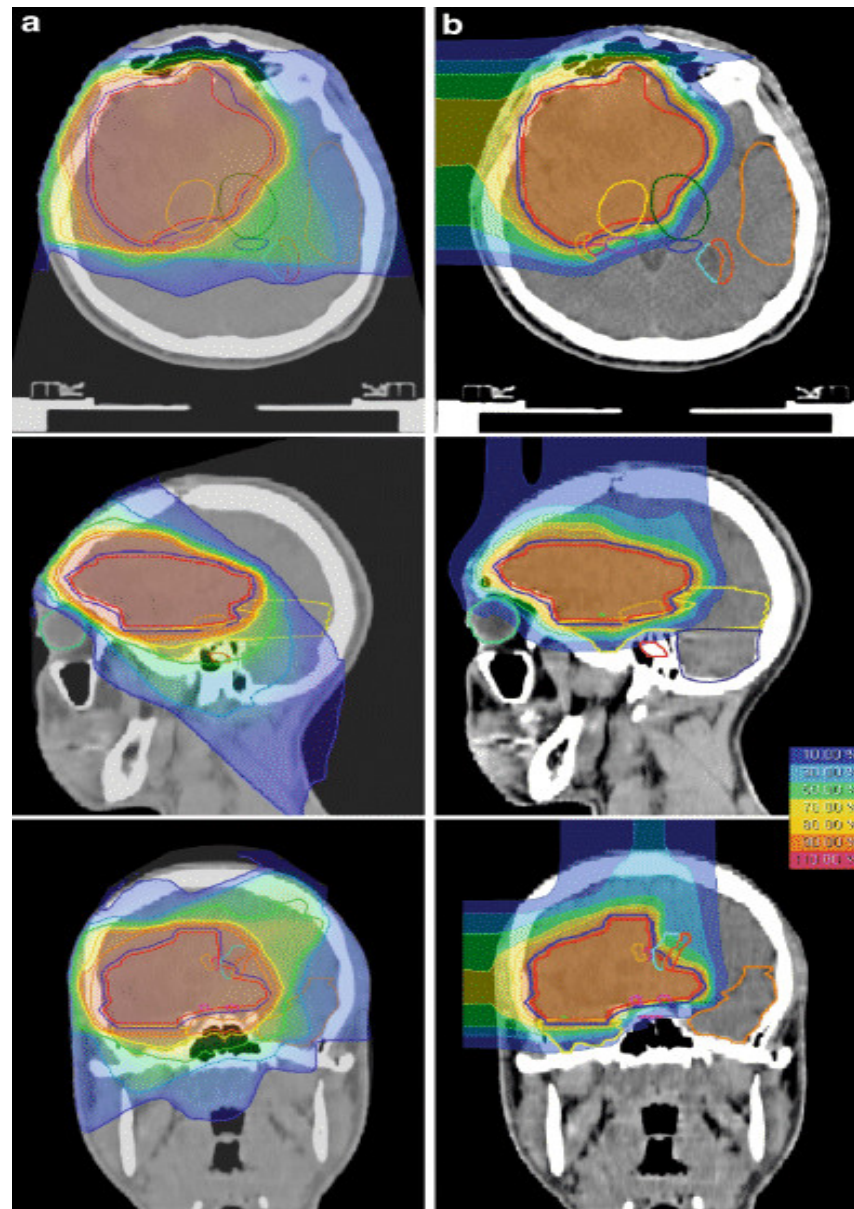


Koerber SA, Slynko A, Haefner MF, Krug D, Schoneweg C, Kessel K, Kopp-Schneider A, Herfarth K, Debus J, Sterzing F. Efficacy and toxicity of chemoradiation in patients with anal cancer--a retrospective analysis. *Radiat Oncol* 2014;9:113.

Radiotherapy of CNS tumors

Low-grade gliomas

- pilocytic astrocytoma WHO grade I,
- subependymal giant cell astrocytoma WHO grade I,
- pleomorphic xanthoastrocytoma WHO grade II,
- diffuse astrocytoma IDH-mutated WHO grade II,
- oligodendroglioma IDH-mutated with 1p/19q codeletion WHO grade II
- **Maximum surgical resection**
- **RT** (residual symptomatic disease or disease progression especially when reoperation is not indicated): TD 50.4-54 Gy, in 28-30 fractions with a daily fraction of 1.8 Gy is standard
- **CHT** (not clearly defined)



Harrabi SB, et al. Dosimetric advantages of proton therapy over conventional radiotherapy with photons in young patients and adults with low-grade glioma. *Strahlenther Onkol* 2016;192(11):759-69.

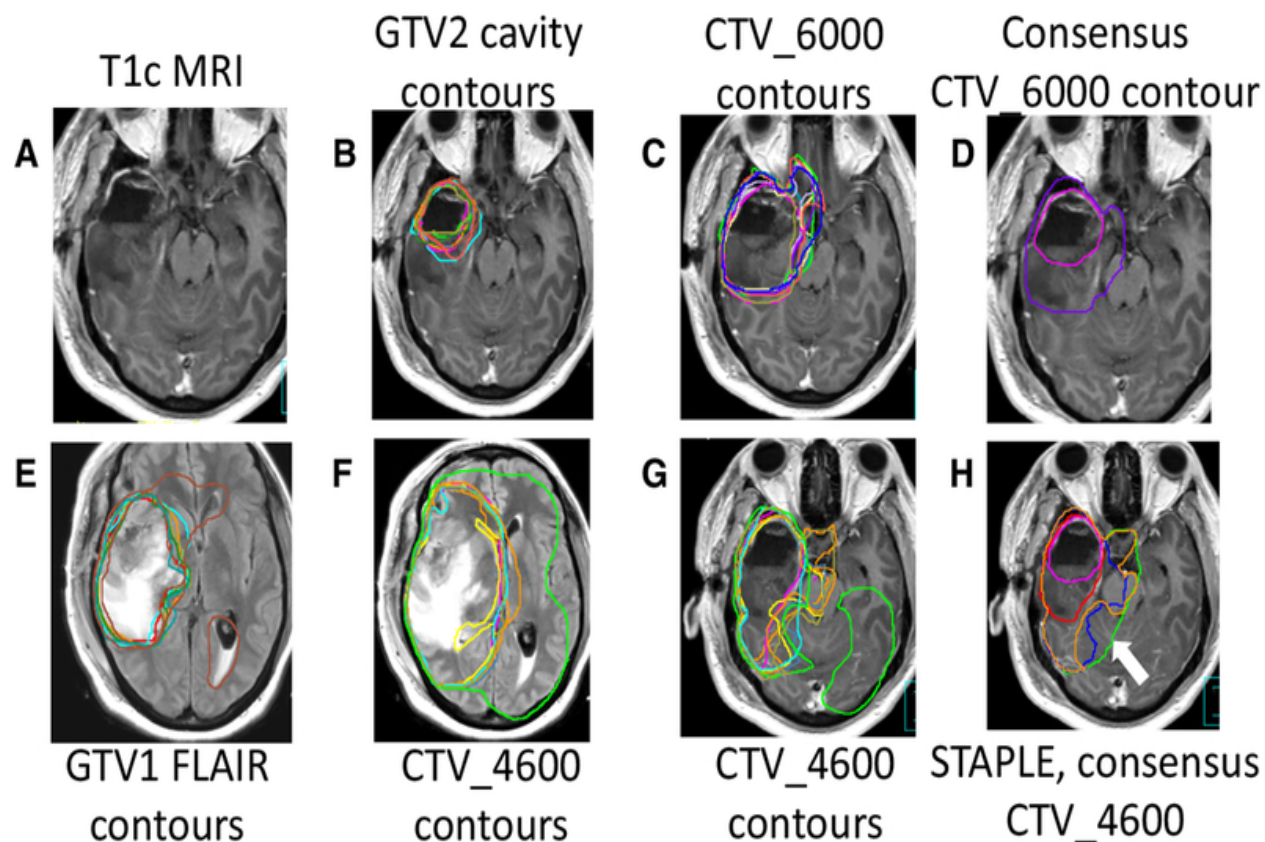
Radiotherapy of CNS tumors

- **High-grade gliomas**
- anaplastic astrocytoma IDH-mutated WHO grade III,
- anaplastic pleomorphic xanthoastrocytoma WHO grade III,
- anaplastic oligodendroglioma IDH-mutated with 1p/19q codeletion WHO grade III,
- glioblastoma IDH-wildtype
- IDH – mutated astrocytoma grade IV

- **Surgery** (maximum tumor resection)
- **CHT** (according to the CCNU or BCNU protocol or concomitantly with temozolomide, which is also continued in the adjuvant approach)
- **RT** (6 weeks from surgery) TD 54-59.4 Gy in 30-33 fractions
- Immunotherapy (VEGF - bevacizumab and VEGF receptor agonist - cediranib)

Radiotherapy of glioblastoma

- **Laser Interstitial Thermal Therapy (LITT)** destruction of tumor cells by the effect of localized high temperature with the help of radiofrequency waves, ultrasound, microwaves and magnetic nanoparticles.
- **Tumor Treating Fields (TTF)** is a technology of creating alternative electrical fields of low intensity (1–3 V/cm) and medium frequency (100–300 KHz) that lead to the interruption of cell division.
- **Immunotherapy**
- **Checkpoint inhibitors** (nivolumab, pembrolizumab, durvalumab, atezolizumab, and pidilizumab)
- **T-Cell Therapy** where T-cells are programmed to express chimeric antigen receptors (CARs).
- **Viral therapy** is a part of immunotherapy in which an oncolytic virus exerts an effect on various mechanisms including direct oncolysis, virus-induced antitumor response, and immunoregulation.
- **The vaccine.** Dendritic cell vaccine activates CD8+ and CD4+ T-lymphocytes, which results in tumor destruction (47).
- **Radiotherapy**
- **Postoperative RT:** TD 60 Gy in 30 fractions concomitant with chemotherapy with temozolomide, an oral alkylating agent that crosses the blood-brain barrier, at a dose of 75 mg/m².
- After completion, adjuvant chemotherapy is carried out up to a total of VI cycles at a dose of 150-200 mg/m² temozolomide for 5 days, and cycles of 28 days. Alternative drugs are cisplatin, carboplatin, etoposide, irinotecan.
- **Palliative RT:** TD 45Gy in 15 fractions or as palliative with TD30 Gy in 6 fractions.



Glioblastom temporalno desno

(A, B) panels show the contrast-enhanced T1 MRI with GTV2 contours (cavity plus enhancement).

(C) CTV_6000 contours demonstrate variability at the interface with the brainstem and optic structures.

(D) the STAPLE GTV2 cavity contour in pink and the consensus CTV_6000 contour.

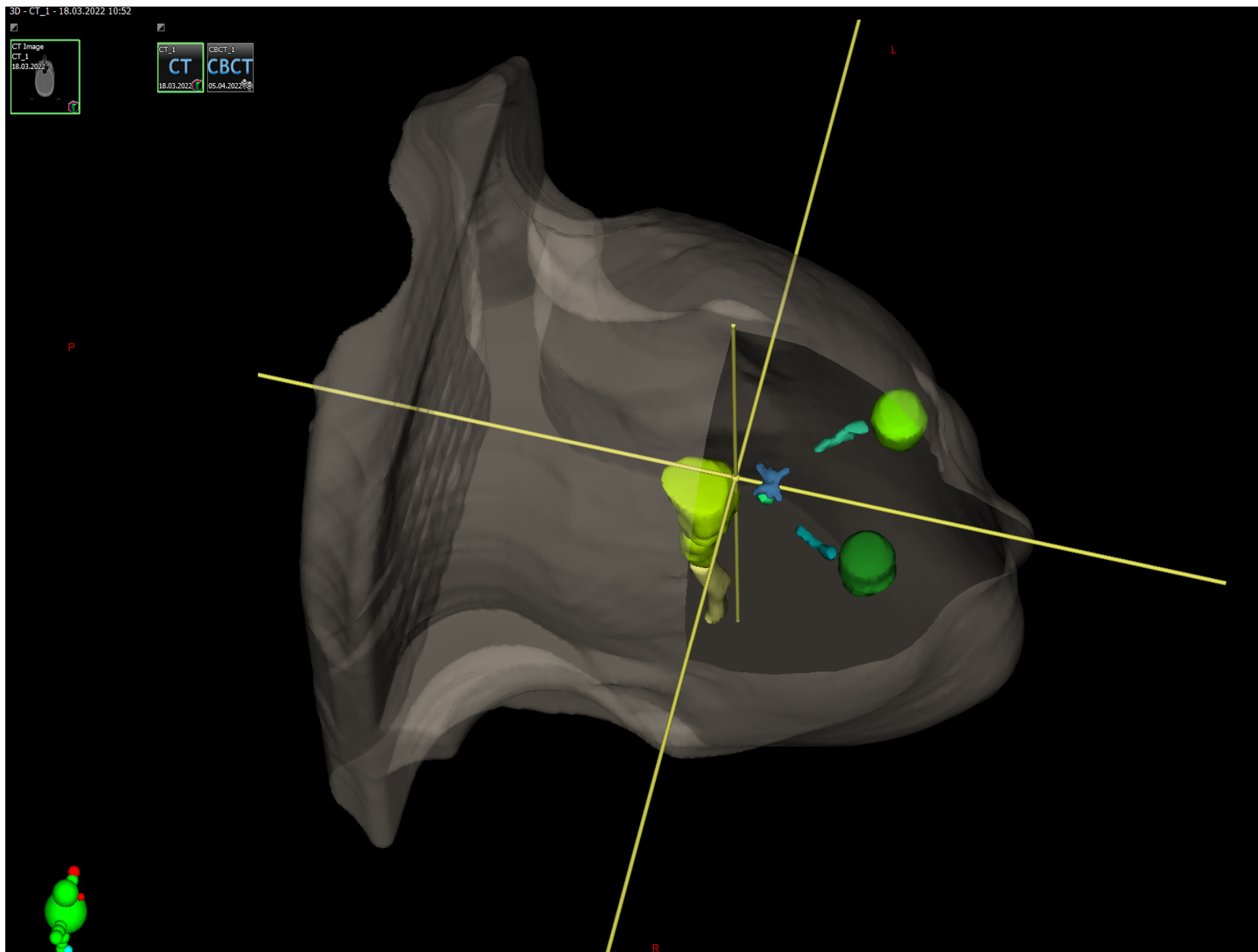
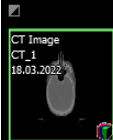
(E, F) show T2 FLAIR MRI images with submitted GTV1 (FLAIR) contours and CTV_4600 contours.

(G) CTV_4600 contours are demonstrated at level of brainstem and optic nerves with significant variation.

(H) CTV1 expansion (without anatomic trimming) in green and mathematical STAPLE contours in blue. The space between the green and orange consensus CTV_4600 contour reflects anatomic trimming off the cerebellum (white arrow) due to cerebellar falx, while maintaining inclusion of optic and brainstem tissue in direct anatomic contiguity with the right temporal T2 FLAIR signal. (*These principles may also be applied to a simultaneous integrated boost approach of 50 Gy and 60 Gy all given in 30 fractions)

Kruser TJ, Bosch WR, Badiyan SN, Bovi JA, Ghia AJ, Kim MM, Solanki AA, Sachdev S, Tsien C, Wang TJC, Mehta MP, McMullen KP. NRG brain tumor specialists consensus guidelines for glioblastoma

3D - CT_1 - 18.03.2022 10:52



3D - CT_1 - 18.03.2022 10:52



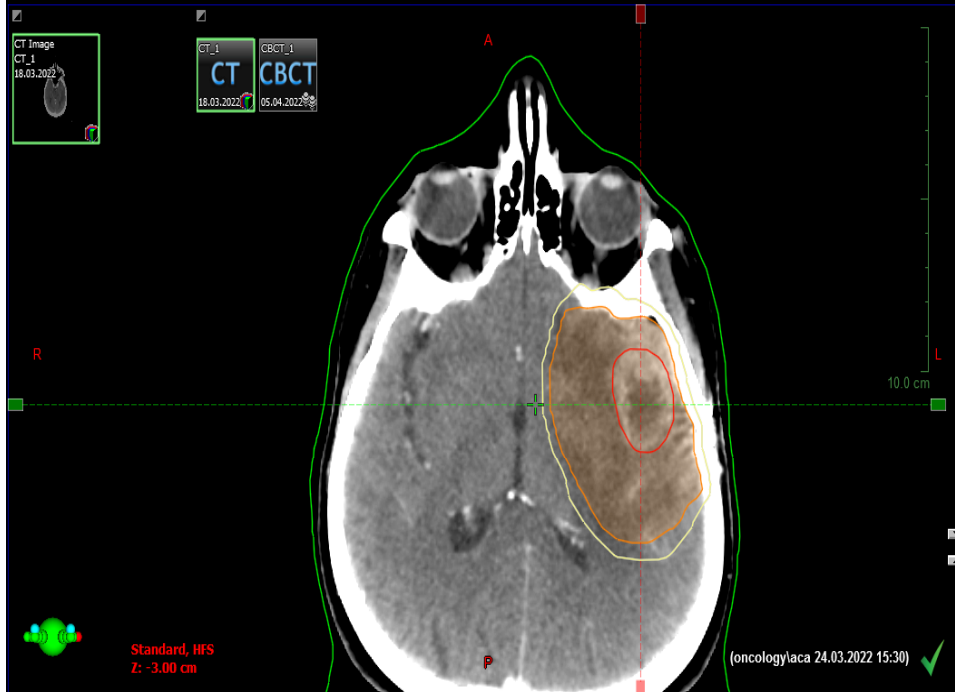
H

R

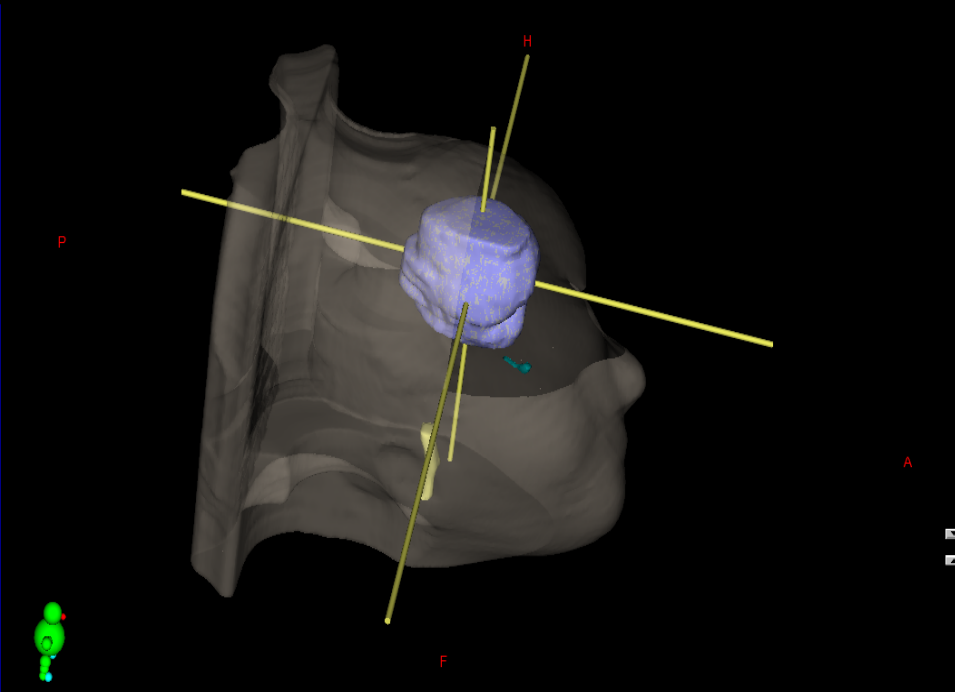


F

Transversal - CT_1 - 18.03.2022 10:52



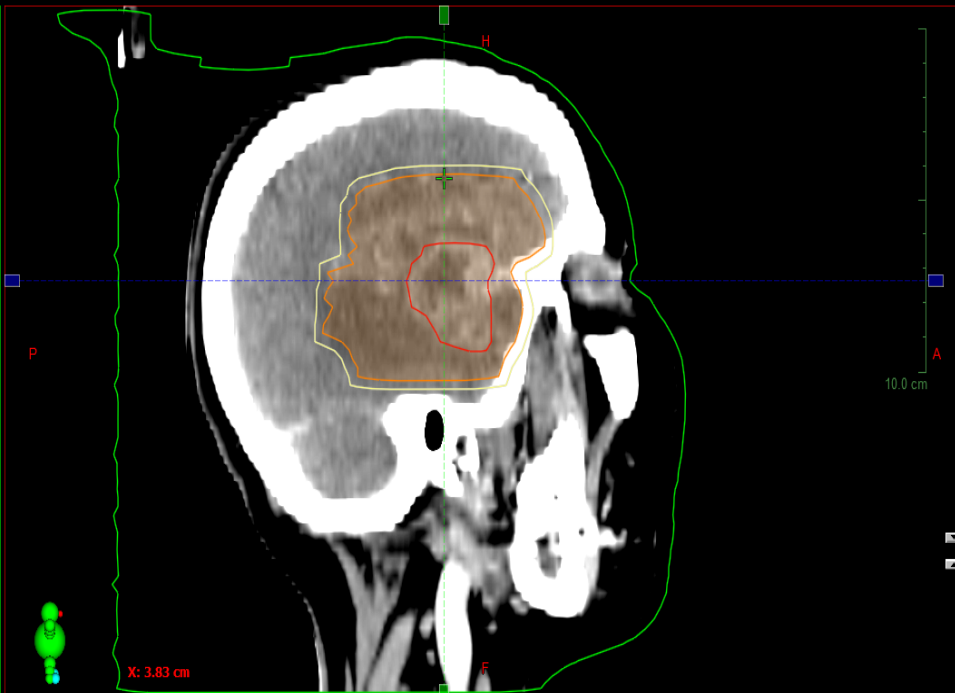
3D - CT_1 - 18.03.2022 10:52

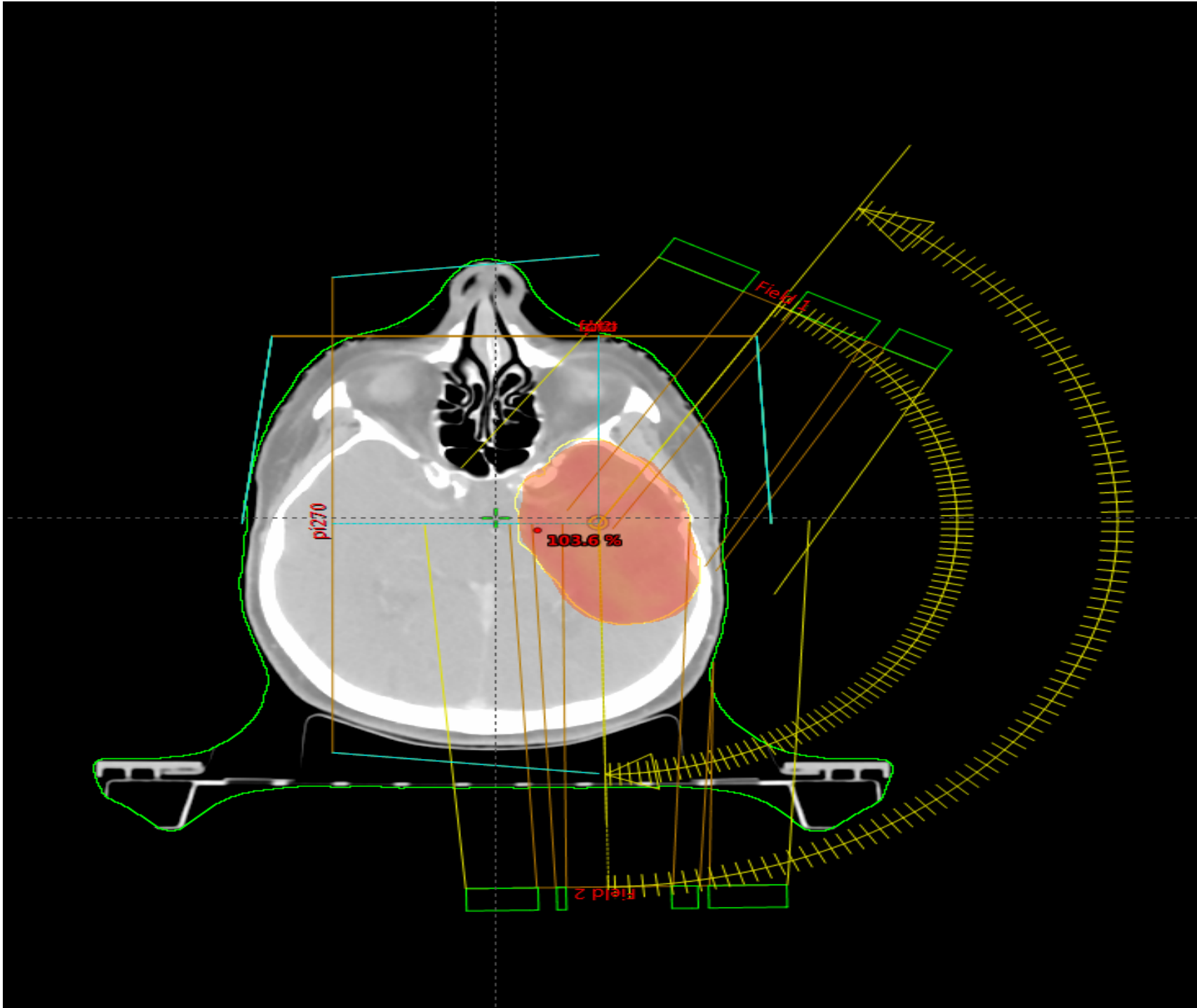


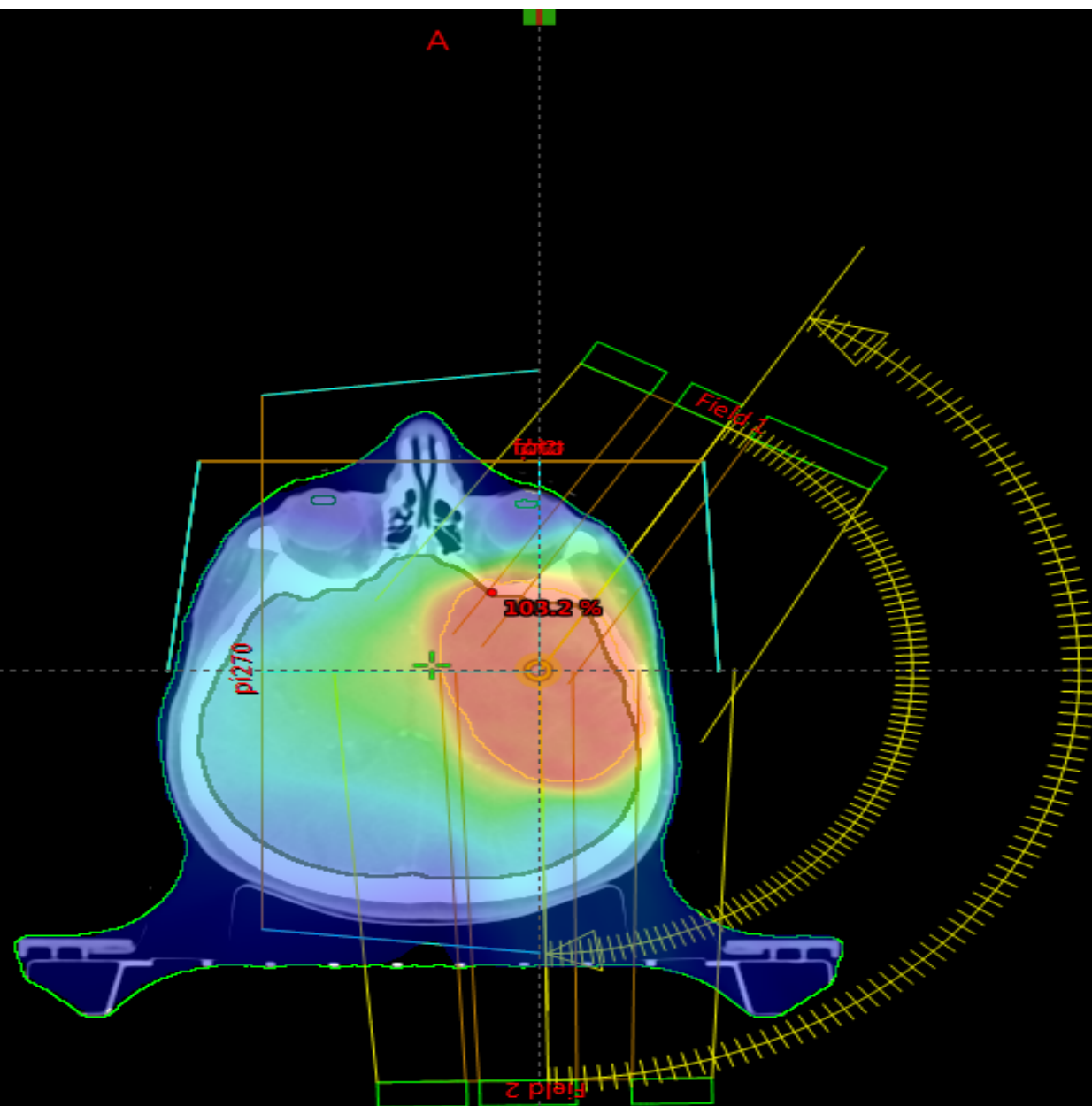
Frontal - CT_1 - 18.03.2022 10:52



Sagittal - CT_1 - 18.03.2022 10:52







VUKLJZZ1318

1

PD RA

PTV : RO

RA

RA

CT_1

Registered Images

CT_1

BODY

Brain

BrainStem

Chiasm

CouchInterior

CouchSurface

CTV_High

Eye_L

Eye_R

GTVp

Lens_L

Lens_R

OpticNerve_L

OpticNerve_R

Pituitary

PTV_High

PTV_High_crop

Skin

SpinalCord

User Origin

Reference Points

PTV_High

Dose

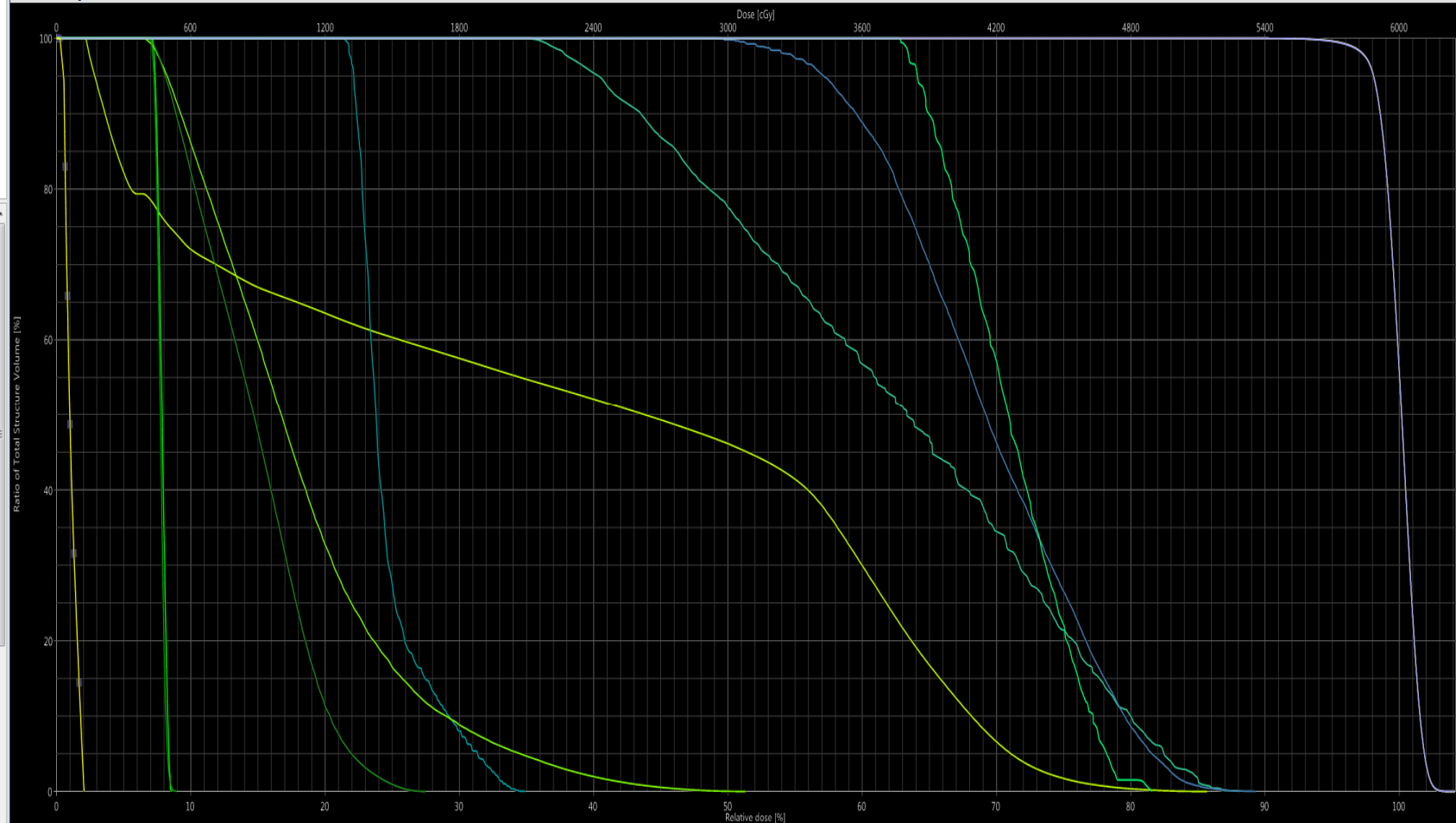
Fields

Isocenter Group 1

pi270

pi270-DRR (Live)

Dose Volume Histogram

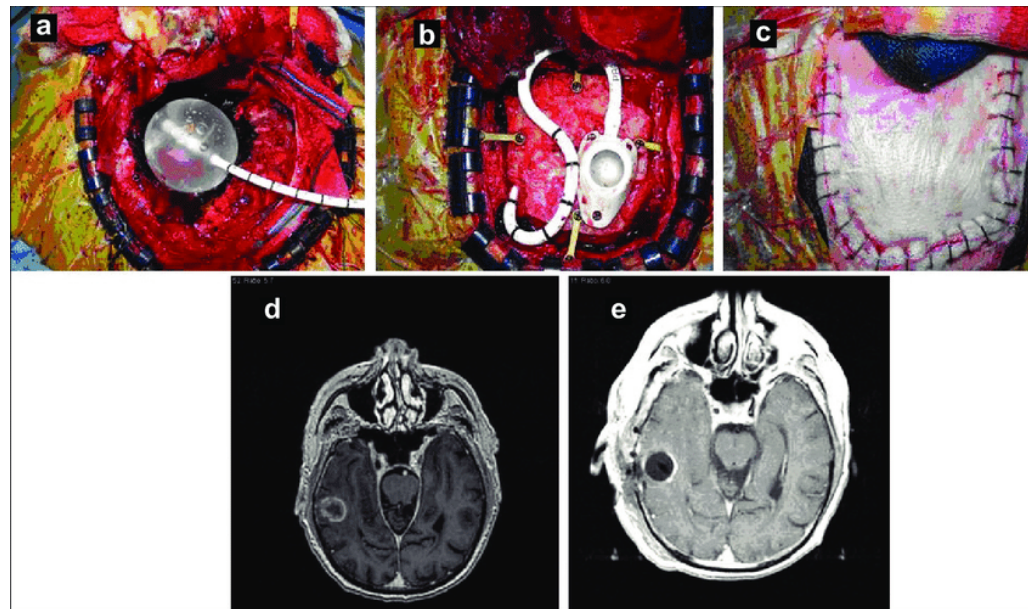


Dose Reference Points Dose Statistics

Show DVH	Structure	Approval Status	Plan	Course	Volume [cm ³]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]
<input type="checkbox"/>	Brain	Approved	RA	1						
<input type="checkbox"/>	BODY	Approved	RA	1		5547.8	100.0	99.9	0.0	104.2
<input type="checkbox"/>	BrainStem	Approved	RA	1		15.8	100.0	100.2	2.1	85.7
<input checked="" type="checkbox"/>	SpinalCord	Approved	RA	1		3.4	100.0	100.5	0.2	2.1
<input checked="" type="checkbox"/>	Pituitary	Approved	RA	1		0.2	100.0	99.2	62.8	81.6
<input checked="" type="checkbox"/>	Chiasm	Approved	RA	1		0.2	100.0	99.3	49.2	89.3
<input checked="" type="checkbox"/>	OpticNerve_R	Approved	RA	1		0.1	100.0	98.3	21.5	34.9
<input checked="" type="checkbox"/>	OpticNerve_L	Approved	RA	1		0.3	100.0	100.2	35.4	88.2
<input checked="" type="checkbox"/>	Lens_R	Approved	RA	1		0.1	100.0	99.7	7.0	9.0
<input checked="" type="checkbox"/>	Lens_L	Approved	RA	1		0.1	100.0	100.1	7.1	8.6
<input checked="" type="checkbox"/>	Eye_R	Approved	RA	1		5.3	100.0	100.0	6.8	27.5
<input checked="" type="checkbox"/>	Eye_L	Approved	RA	1		5.1	100.0	100.0	6.4	51.4
<input checked="" type="checkbox"/>	GTVp	Approved	RA	1						
<input type="checkbox"/>	CTV_High	Approved	RA	1						
<input checked="" type="checkbox"/>	PTV_High	Approved	RA	1		199.9	100.0	100.0	85.2	104.2
<input type="checkbox"/>	Skin	Approved	RA	1						
<input checked="" type="checkbox"/>	PTV_High_crop	Approved	RA	1		199.8	100.0	100.0	85.2	104.2

Brachytherapy in high grade glioma

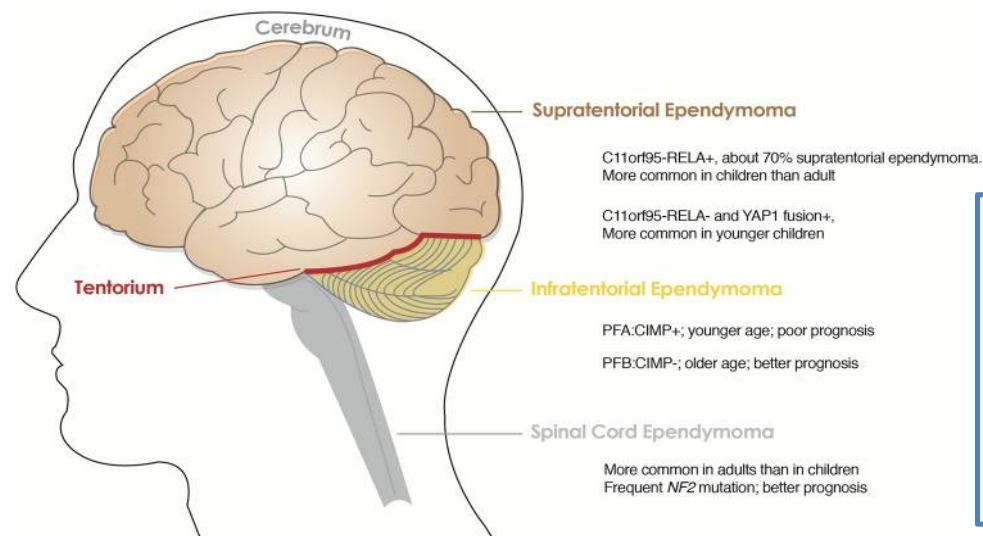
- Boost after EBRT
- Glia Site Radiation Therapy System (Cytac, Marlborough, MA)
- 1-2 weeks after implantation after the placed catheters are filled with aqueous solution ^{125}I .
- TD of 40 to 60 Gy in 3 to 6 days, after which the device is displaced.



Wernicke AG, et al. Feasibility and safety of GliaSite brachytherapy in treatment of CNS tumors following neurosurgical resection. J Cancer Res Ther 2010;6(1):65-74.

Radiotherapy of ependymoma

Supratentorial ependymomas	ZFTA, RELA, YAP1, MAML2
Posterior fossa ependymomas	H3 K27me3, EZHIP (methylome)
Spinal ependymomas	NF2, MYCN



Molecular-biological characteristics of supratentorial, infratentorial and ependymoma of the spinal cord WHO grades II and III.

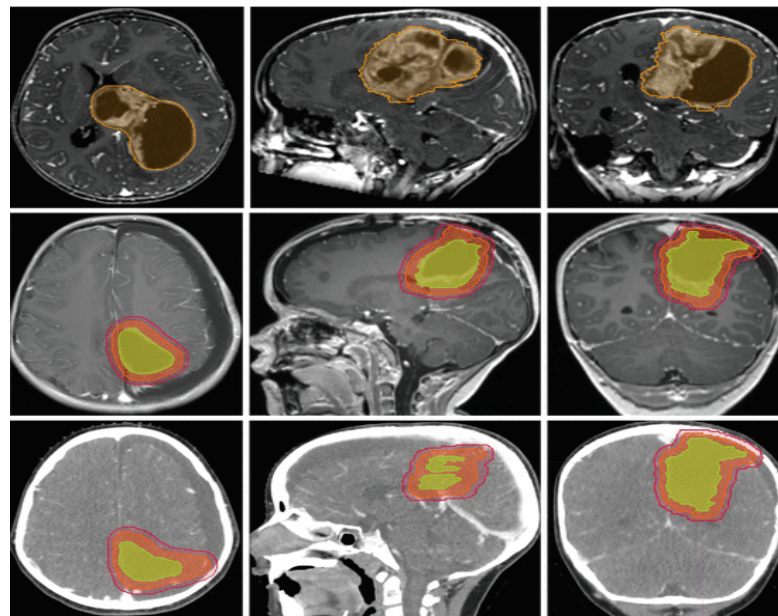
- Anywhere in the CNS (most commonly within the IV ventricle)
- Low-grade supratentorial → **local RT**
- High-grade supra and infraten → **CSI + boost**
- Low-grade infratentorial - **a controversy?**

Wu J, Armstrong TS, Gilbert MR. Biology and management of ependymomas. Neuro Oncol 2016;18(7):902-13.)

Louis DN, Perry A, Wesseling P, Brat DJ, Cree IA, Figarella-Branger D, Hawkins C, Ng HK, Pfister SM, Reifenberger G, Soffietti R, von Deimling A, Ellison DW. The 2021 WHO Classification of Tumors of the Central Nervous System: a summary. Neuro Oncol. 2021 Aug 2;23(8):1231-1251.

Treatment of ependymoma

- **RT**
- craniospinal RT with a TD of 35 to 45 Gy with a boost to areas of primary tumor and active disease up to a total dose of TD of 50.4 to 54 Gy
- **CHT** – limited efficacy, High-grade tumors, resistant to other treatment modalities
- **Surgery** (subtotal resection) + II Cy (HT) + second-look operation



Slika dostuona na:
<https://oncohemakey.com/ependymoma-4/>

Radiotherapy of meningioma

Meningiomas

NF2, AKT1, TRAF7, SMO, PIK3CA; KLF4, SMARCE1, BAP1 in subtypes; H3K27me3; TERT promoter, CDKN2A/B in CNS WHO grade 3

- Benign (grade I): few mitosis, slow growth, rare relapse, 10-year progression-free survival is 80%,
- Atypical (grade II): more aggressive than benign, more mitoses, 7-8 times higher risk of relapse than grade I, 10-year progression-free survival is 40-60%,
- Anaplastic (grade III): invasive, poor prognosis; median relapse-free survival is less than 2 years
- Treatment
- **Surgery**
- **Radiotherapy**: unresectable or incompletely resectable tumors due to localization (skull base, cavernous sinus, cerebellopontine angle), the patient does not agree to surgery or it is medically contraindicated. Adjuvant approach in subtotal resection of benign and all atypical and malignant meningiomas
- Dosage prescription:
 - Meningioma grade I: 50-54 Gy in 25-30 fractions
 - Meningioma grade II and III: 60 Gy in 30-33 fractions
 - Meningioma of the optic nerve: 50-54 Gy in 25-30 fractions
 - Stereotaxic radiosurgery: 12-20 Gy in one fraction depending on the proximity of critical structures (12 Gy for tumors close to critical structures such as the brainstem, 15-20 Gy if the tumor is not close to extremely critical structures). Doses depend on the size of the tumor: 18 Gy (<1 cm), 16 Gy (1-3 cm), 12-14 Gy (>3 cm)
- **CHT**: in tumor progression after RT and in case of recurrent disease (cyclophosphamide, adriamycin, vincristine, interferon-alpha).

Radiotherapy of tumors of the sellar region

Tumors of the sellar region
Adamantinomatous craniopharyngioma
Papillary craniopharyngioma
Pituicytoma, granular cell tumor of the sellar region, and spindle cell oncocytoma
Pituitary adenoma/PitNET
Pituitary blastoma

Craniopharyngioma

Benign tumor of epithelial origin - remnant of Rathke's sac

Surgery

Total resection - curative → postoperative morbidity and mortality

GTR is not always feasible

Recommendation → limited surgical decompression + postoperative RT

Recurrent tumor with a large cystic component

Intracavitary brachytherapy (Beta emitters ^{32}P and ^{90}Yt and Gamma-Beta emitters ^{186}Ph and ^{198}Au)

Pituitary adenoma

Surgical resection for Tu \leq 1 cm – the therapy of choice

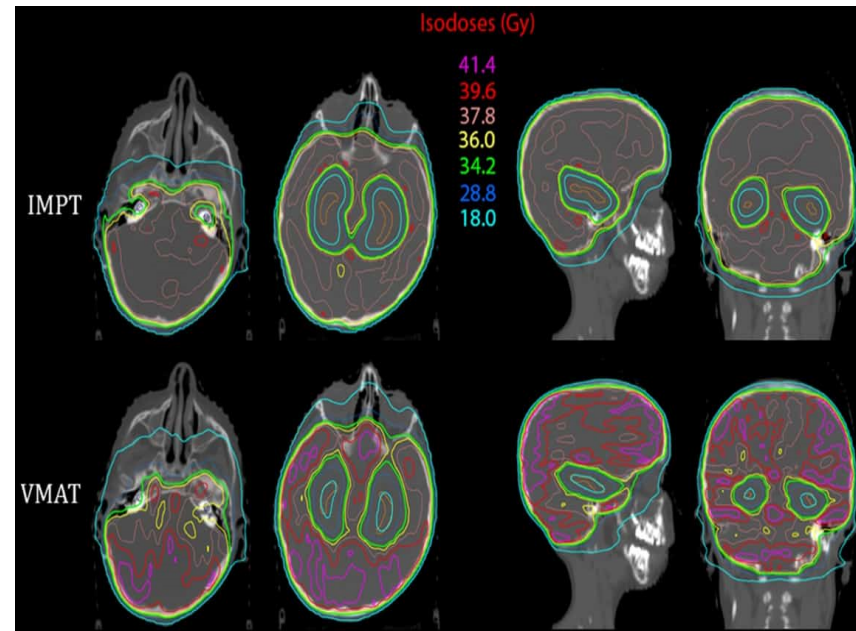
Radiotherapy after partial resection

Most patients - hormone replacement therapy with dopamine agonists (bromocriptine, Cabergoline, quinagolide, Pergolide) - reduction in tumor size and improvement of symptoms

RT: 50-54 Gy in 30 fractions, and dose per fraction 1.67-1.8 Gy

Radiotherapy of intracranial germ cell tumors

- Germinomas
- Embryonic carcinoma
- Choriocarcinoma
- Endodermal sinus tumor
- Teratoma / teratocarcinoma
- Mixed germ cell tumors



Courtesy: J Stoker et al Phys. Imag. Radiat. Oncol.
10.1016/j.phro.2018.11.001

Radiotherapy of central nervous system lymphoma

- **PCNSL in immunocompetent and**
- **PCNSL in immunocompromised patients (occurring in congenital or acquired immunodeficiency)**
- **CHT** - standard in definitive treatment (with or without RT), salvage therapy in disease progression or recurrent disease and as definitive treatment in ocular lymphomas. High doses of methotrexate > 1g/m².
- **RT** after HT or as definitive treatment in patients unfit for chemotherapy (KPS≤40, creatinine clearance <50%) and as definitive treatment for ocular lymphomas.
- irradiation of the entire endocranium with or without administration of a boost dose
- If a CR response is achieved: whole brain RT with 24-36Gy (1.5-2Gy). Consider dose reduction or discontinuation of treatment in patients over 60 years of age due to possible serious neurotoxicity.
- If CR response not achieved: RT to whole brain with 24-36Gy (1.8-2Gy) with boost to residual disease up to 45Gy (1.8-2Gy).
- If it was not possible to apply chemotherapy:
- Whole brain RT up to 45Gy (1.8-2Gy)

Head and neck cancer radiotherapy

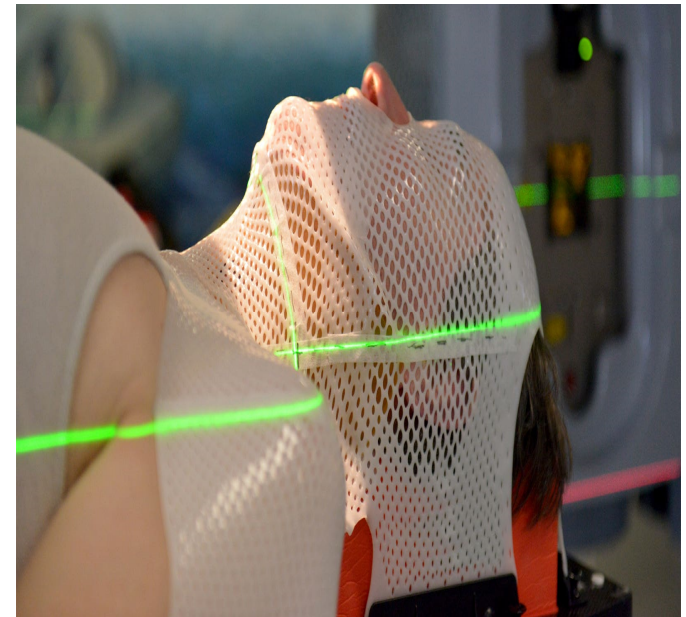
- Oral cavity
- Oropharynx
- Epipharynx
- Hypopharynx
- Larynx
- Paranasal sinuses
- Salivary glands
- Regional lymph nodes - neck levels from I-VI +

Head and neck cancer definitive radiotherapy

For unresectable head and neck tumors, radical RT ± CHT

- Locally advanced tumors of CS III and IV
- Locally advanced tumors after neoadjuvant CHT and achieved partial response (PR)
- Resectable tumors with the goal of organ preservation RT + CHT
- (Optional: concomitant Cetuximab biotherapy)

Definitive RT in early stages (results similar to surgery)

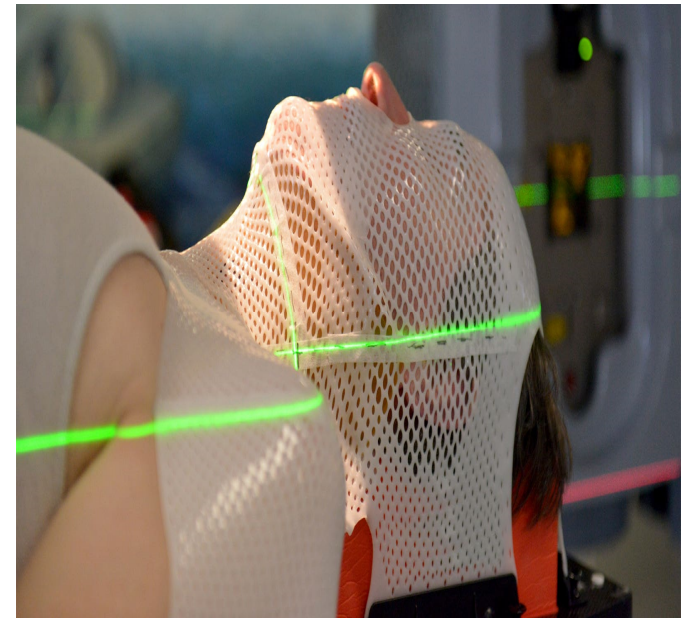


Slika dostupna na: Radiation Speeds Up Biological Aging in Head and Neck Cancer. At: <https://www.medpagetoday.com/hematologyoncology/othercancers/92872>

Head and neck cancer postoperative radiotherapy

Postoperative RT ± CHT potentiation

- positive resection margins
- lymphnodal metastases
- extracapsular spread in lymphnodal metastases
- close resection margin (<5mm)
- soft tissue and skeletal muscle invasion
- multicentric primary tumor
- perineural invasion
- lymphovascular invasion
- poor histological differentiation of the tumor (G3)
- T3-T4 tumors



Slika dostupna na: Radiation Speeds Up Biological Aging in Head and Neck Cancer. At: <https://www.medpagetoday.com/hematologyoncology/othercancers/92872>

Head and neck cancer radiotherapy

Radical dose: 66-70 Gy in 33-35 fractions

Postoperative dose:

High-risk region: 64-66 Gy in 32-33 fractions

Intermediate risk region: 60 Gy in 30 fractions

Low-risk region: 44-50 Gy in 22-25 fractions

With the simultaneous integrated boost (SiB) technique:

High-risk region: 70 Gy in 33 fractions

Intermediate risk region: 60 Gy in 33 fractions

Low-risk region: 50-54 Gy in 33 fractions

Alternative dose prescription for the SiB technique:

High-risk region: 70 Gy in 35 fractions

Intermediate risk region: 63 Gy in 35 fractions

Low-risk region: 56 Gy in 35 fractions

Radiotolerance of organs at risk according to the QUANTEC study

- **Spinal cord** $D_{max} \leq 45$ Gy (optional ≤ 50 Gy)
- **Eye lens** $D_{max} \leq 8$ Gy (optional $D_{max} \leq 10$ Gy)
- **Optic nerve/chiasm** $D_{max} < 55$ Gy
 $D_{mean} < 50$ Gy
- **Mandible** $D_{max} < 70$ Gy
- **Cochlea** $D_{mean} \leq 45$ Gy
- **Parotid glands**
- When one parotid gland is spared:
 $D_{mean} < 20$ Gy
- When both parotid glands are spared:
 $D_{mean} < 25$ Gy
- **Brain** $D_{max} < 60$ Gy
- **Brachial plexus** $D_{max} < 60$ Gy
- **Esophagus** $V_{35} < 50\%$; $D_{max} < 74$ Gy
- **Larynx** $D_{mean} < 44$ Gy; $V_{50} < 27\%$

Benign conditions – indications for radiotherapy

- RT for non-malignant indications certainly has a place in modern medicine, and there is considerable evidence for the utility of low- to intermediate-dose RT for treating a range of specific indications.
- RT at these doses is relatively easy to administer, has few symptomatic side effects and often provides good long-term control and improved quality of life
- Consequently, although the doses required to treat benign disease are generally lower than those used to treat cancer, caution is advised when considering RT for these conditions in children and young adults.

Table 1. Benign diseases for which intermediate dose radiotherapy has utility

Benign disease	Pathology	Predominant age groups (years)	Approximate total dose (Gy) ^a	At-risk normal tissues ^b	Comments	Study
Ocular disease						
Pterygium	Fibrovascular proliferating tissue	Early 20s to old age	20–50	Lens, sclera, anterior brain structures	Surgery is preferred option; adjuvant RT can improve outcome	Ali et al ¹
Choroidal haemangioma	Proliferation of normal vasculature	30–50	20	Lens, anterior brain structures	Rarely used; would require discussion in specialist centre	Frau et al ²
Age-related macular degeneration	Neovascularization	>65	20	Lens, anterior brain structures	No longer routinely used, but subject to ongoing research	Evans et al ³
Reactive lymphoid hyperplasia/orbital pseudotumour	Idiopathic orbital inflammation	Median 40–50	20	Orbit, anterior brain structures	Steroids are first line treatment. RT effective if inadequate response to steroids	Mendenhall and Lessner ⁴
Thyroid eye disease	Autoimmune	20–40	20	Orbit, anterior brain structures	Steroids are first line treatment. RT considered if impaired mobility/diplopia	Bartalena et al ⁵
Orthopaedic/musculoskeletal disease						
Heterotopic ossification of the hip	Extraskelatal new bone formation	50–80	7	Pelvic bones and muscles	Adjuvant post-surgery	Lo et al ⁶
Plantar fasciitis	Inflammation and degeneration	40–60	3–6	Tissues of foot (skin, muscle)	RT indicated if failed conservative management for 6–12 months	Heyd et al ⁷ and Niewald et al ⁸
Aneurysmal bone cyst	Benign osteolytic bone lesion	Children and young adults	30	Bone, other tissues depending on site	Rarely used; useful for cysts in anatomically difficult locations and for recurrence following surgery	Heyd and Seegenschmiedt ⁹
Vertebral haemangiomas	Benign vascular proliferation	All ages	36–40	Bone, soft tissue, spinal cord	Rarely used; evidence suggests useful for control of pain relief	Taylor et al ¹⁰ and Heyd et al ¹¹
Keloid	Abnormal fibroblasts, reduced apoptosis, increased collagen and cytokines	10–30	5–12	Depends on site of keloid	Adjuvant post-surgery	Ragoowansi et al ¹²
Dupuytren's disease	Benign fibroblastic proliferation of the palmar fascia	50–70	30	Tissues of hand (skin, muscle)	In early progressive disease, prevents progression and need for surgery	Seegenschmiedt et al ¹³
Ledderhose disease (plantar fibromatosis)	Benign fibroblastic proliferation of the plantar fascia	20–40	30	Tissues of foot	RT reduces pain and improves function	Seegenschmiedt et al ¹⁴
Pigmented nodular synovitis	Proliferation of synovial membranes	20–40	35–40	Depends on site	May also be suitable for instillation of radionuclide	O'Sullivan et al ¹⁵

(Continued)

Benign disease	Pathology	Predominant age groups (years)	Approximate total dose (Gy) ^a	At-risk normal tissues ^b	Comments	Study
Peyronie's disease	Wound healing disorder of tunica albuginea of the penis	30–70	9–30	Lower pelvis	Currently rarely used; can be useful for pain relief in intractable case	Taylor et al ¹⁰ and Niewald et al ¹⁶
Chronic eczema	Pruritic chronic inflammatory skin disease	All	4–5	Various; depends on site of lesions	Only very rarely recommended for intractable condition in adults	Taylor et al ¹⁰ and Sumila et al ¹⁷
Lentigo maligna	Atypical melanocyte proliferation	>60	45–50	Various; depends on site of lesion	Surgery preferred option; when contraindicated RT can provide good outcome	Tsang et al ¹⁸
Psoriasis	Autoimmune T-cell-mediated disorder	All ages from young adult	6–8	Various; depends on site of lesions	Rarely used; some evidence for utility in recalcitrant disease particularly involving nail beds	De Vries et al ¹⁹
Trigeminal neuralgia (SRS)	Uncertain	Peak 60–70 (>90% over age 40 years)	Max. point dose 80–90	Brainstem	Very small treatment field, usually carried out with Gamma Knife	Taylor et al ¹⁰
Meningioma	Benign tumour	Wide age range; incidence increases with age	50–55 (or 14 Gy for SRS)	Various; depends on site of lesion	SRS tends to be for smaller lesions, particularly in base of skull	Taylor et al ¹⁰
Arteriovenous malformation in brain (SRS)	Vascular anomaly	10–40	Ideally >20 for SRS	Various; depends on site of lesion	Can occur throughout brain and vary in size. Treatment more effective and safer with smaller lesions	Taylor et al ¹⁰
Acoustic schwannoma	Benign tumour	Majority over 40	12 (SRS) 45–56	Brainstem, facial nerve, cochlea	Other options include surgery or surveillance depending on size, hearing and rate of growth	Combs et al ²⁰
Head and neck						
Sialorrhoea	Excessive drooling often because of severe neurological disorder	Elderly	10–20	Oral cavity/oropharynx, parotid	RT is effective at reducing saliva flow. RT can be used if anti-cholinergics and/or botulinum toxin ineffective	Assouline et al ²¹
Salivary pleomorphic adenoma	Benign tumour of the salivary gland	30–60	50	Adjacent head and neck structures, e.g. oropharynx	Surgery with clear margins offers high local control. Adjuvant RT improves local control in high-risk patients (with positive margins/recurrent disease)	Mendenhall et al ²²
Glomus tumour	Paraganglioma, benign vascular tumour	Median 50	45	Adjacent head and neck structures, e.g. nasopharynx, oropharynx	Surgery or RT offer high rates of local control	Mendenhall et al ²³

Benign disease	Pathology	Predominant age groups (years)	Approximate total dose (Gy) ^a	At-risk normal tissues ^b	Comments	Study
Juvenile nasopharyngeal angiofibroma	Rare benign vascular tumour	Median 14	35–45	Adjacent head and neck structures, e.g. nasopharynx, oropharynx	Surgery is treatment of choice. RT effective if unresectable. Surgery or RT considered for recurrence	Chakraborty et al ²⁴
Miscellaneous						
Hidradenitis suppurativa	Chronic inflammatory/infective	Young adult	10	Depends on site	Only to be considered in refractory cases	Fronlich et al ²⁵
Gynaecomastia	Breast tissue hyperplasia	>60	10	Breast tissue, skin, lungs	Occurs in males on hormonal therapy for prostate cancer	Viani et al ²⁶

RT, radiotherapy; SRS, stereotactic radiosurgery.

This provides a summary of benign diseases for which intermediate dose RT has utility. Benign diseases that are no longer treated with RT are not included but are discussed elsewhere in the text.

^aThe total dose is only indicative and can vary considerably between centres and in different countries.

^bIt is assumed that skin is normally at risk; any other “at-risk” normal tissues are indicated, although these can vary in some situations. For detailed discussion of RT regimens, risks of RT and comparisons with other treatment options, see Taylor et al.¹⁰

Radiotherapy of soft tissue tumors

- Fibrous tissue
 - Fat tissue
 - Blood vessels
 - Smooth and striated muscles
 - Tendons and cartilage
 - Tumors of peripheral glands
-
- 40% occur on the extremities
 - 70% in this group is above the knee
 - 10% in the retroperitoneum
 - 20% chest and abdominal wall
-
- Treatment:
 - Surgery
 - Radiotherapy
 - Chemotherapy

Histological subtypes

Adipocytic tumours

Fibroblastic and myofibroblastic tumours

Fibrohistiocytic tumours

Vascular tumours

Pericytic (perivascular) tumours

Smooth muscle tumours

Skeletal muscle tumours

Gastrointestinal stromal tumours

Chondro-osseous tumours

Peripheral nerve sheath tumours

Tumours of uncertain differentiation

Undifferentiated small round cell sarcomas

Review

The 2020 WHO Classification of Soft Tissue Tumours: news and perspectives

Marta Sbaraglia¹, Elena Bellan¹, Angelo P. Dei Tos^{1,2}

Major changes in the 2020 WHO classification.

TUMOUR CATEGORY	MAJOR CHANGES	Age & Distribution of new entities
Adipocytic	Addition of atypical spindle cell/pleomorphic lipomatous tumour in benign tumours Addition of myxoid pleomorphic liposarcoma in malignant tumours Recognition of adverse prognostic features in dedifferentiated liposarcoma	Limbs Children and young adults, Mediastinum
Fibroblastic and myofibroblastic tumours	Locally aggressive and malignant variety of solitary fibrous tumour introduced Pathognomic genetic mutations of SFT identified and predictors of recurrence and metastases enumerated Angiofibroma of soft tissues introduced as a benign tumour Superficial CD34 positive fibroblastic tumour added in rarely metastasizing category Ewsr1- Smad3 Positive Fibroblastic Tumour	Lower extremity, middle-age females Lower extremities, middle-aged adults Females, superficial location in hands and feet
Vascular	Epithelioid Hemangioendothelioma with YAP1- TFE3 fusion in malignant category	Young adults, head and neck
Smooth muscle tumour	Smooth muscle tumour of uncertain malignant potential added Inflammatory leiomyosarcoma designated as a separate entity	Young adults, Extremities and trunk
Skeletal muscle tumour	Ectomesenchymoma reclassified as skeletal muscle tumour	
Peripheral nerve sheath tumour	Melanotic schwannoma reclassified as Melanotic malignant peripheral nerve sheath tumour Ectomesenchymoma reclassified as skeletal muscle tumour Addition of malignant perineurioma and removal of malignant triton tumour	Adults, spinal or autonomic nerve
Chondro-osseous tumours	Removal of mesenchymal chondrosarcoma which has been classified as bone tumour	
Tumours of uncertain differentiation	Acral fibromyxoma reclassified as fibroblastic tumour and removal of ectopic hamartomatous thymoma Addition of angiomyolipoma in benign and epithelioid angiomyolipoma in locally aggressive category Phosphaturic mesenchymal tumours reclassified from rarely metastasizing group into benign and malignant varieties Addition of NTRK rearranged spindle cell neoplasm in malignant category Merging of undifferentiated/unclassified sarcomas	Children, extremities or trunk

Histological grading according to FNCLCC	
Tumour differentiation	
Score 1	Closely resembling normal tissue
Score 2	Histological typing is certain
Score 3	Embryonal or undifferentiated sarcomas
Mitotic count (per 1.7 mm ²)	
Score 1	0-9 mitoses per 1.7 mm ²
Score 2	10-19 mitoses per 1.7 mm ²
Score 3	>19 mitoses per 1.7 mm ²
Tumour necrosis	
Score 0	No necrosis
Score 1	<50% tumour necrosis
Score 2	≥50% tumour necrosis
Histological grade	Grade 1: total score 2, 3 Grade 2: total score 4, 5 Grade 3: total score 6, 7, 8

Fig. 1.7

FNCLCC, Fédération Nationale des Centres de Lutte Contre le Cancer.

A) Appendicular skeleton, trunk, skull and facial bones (4)

Definition of primary tumor (T)

T Category	T Criteria
TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
T1	Tumor ≤8 cm in greatest dimension
T2	Tumor >8 cm in greatest dimension
T3	Discontinuous tumors in the primary bone site

Definition of regional lymph node (N)

N Category	N Criteria
NX	Regional lymph node cannot be assessed
N0	No regional lymph node metastasis
N1	Regional lymph nodes metastasis

Definition of distant metastasis (M)

M Category	M Criteria
M0	No distant metastasis
M1	Distant metastasis
M1a	Lung
M1b	Bone or other distant sites

Histologic Grade (G)

G	G Definition
GX	Grade cannot be assessed
G1	Well differentiated, low grade

B) Spine (4)

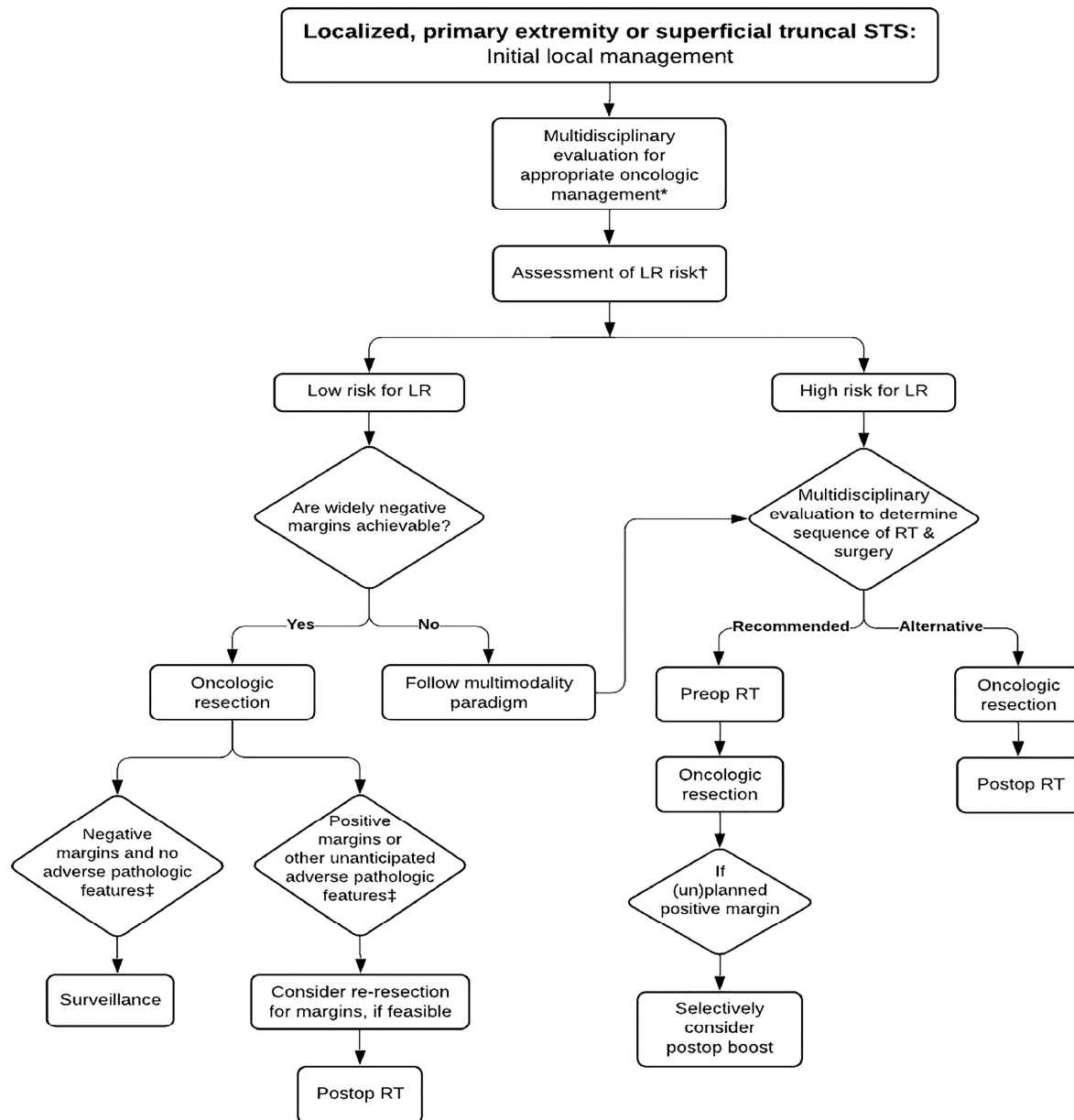
Definition of primary tumor (T)

T Category	T Criteria
TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
T1	Tumor confined to one vertebral segment or two adjacent vertebral segments
T2	Tumor confined to three adjacent vertebral segments
T3	Tumor confined to four or more adjacent vertebral segments, or any nonadjacent vertebral segments
T4	Extension into the spinal canal or great vessels
T4a	Extension into the spinal canal
T4b	Extension of gross vascular invasion or tumor thrombus in the great vessels

C) Pelvis (4)

Definition of primary tumor (T)

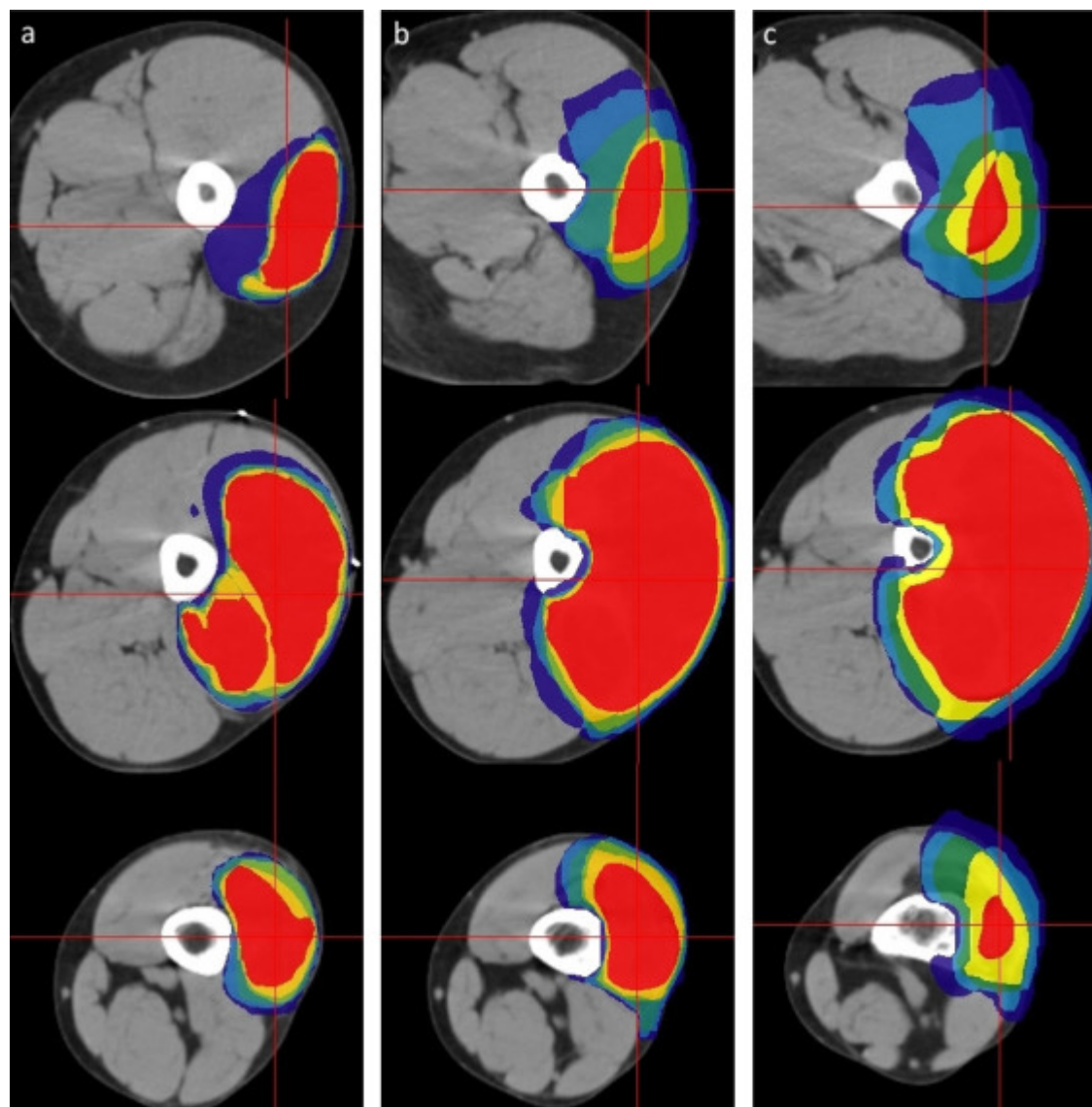
T Category	T Criteria
TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
T1	Tumor confined to one pelvic segment with no extraosseous extension
T1a	Tumor ≤8 cm in greatest dimension
T1b	Tumor >8 cm in greatest dimension
T2	Tumor confined to one pelvic segment with extraosseous extension or two segments without extraosseous extension
T2a	Tumor ≤8 cm in greatest dimension
T2b	Tumor >8 cm in greatest dimension
T3	Tumor spanning two pelvic segments with extraosseous extension
T3a	Tumor ≤8 cm in greatest dimension
T3b	Tumor >8 cm in greatest dimension
T4	Tumor spanning three pelvic segments or crossing the sacroiliac joint
T4a	Tumor involves sacroiliac joint and extends medial to the sacral neuroforamen
T4b	Tumor encasement of external iliac vessels or pres-



Salerno KE, et al. Radiation Therapy for Treatment of Soft Tissue Sarcoma in Adults: Executive Summary of an ASTRO Clinical Practice Guideline. *Pract Radiat Oncol* 2021 ;11(5):339-51.

Grade FNCLCC G1-3	Margin	Depth	Radiotherapy
G1	Wide	sc/deep	No
G1	Marginal	sc	No
G1	Marginal	deep	Consider RT
G2-3	Wide	sc	Consider RT
G2-3	Wide	deep	RT 50 Gy/25 fractions
G2-3	Marginal	sc/deep	RT 50 Gy/25 fractions
G1-3	Intralesional: micro/macro positive	sc/deep	RT 60 -70 Gy (2 Gy fractions)
G1-G3	Inoperable	sc/deep	64-70 (74) Gy (2 Gy fractions)

Table 6. Recommendation for adjuvant radiotherapy in patients with extremity and trunk wall soft tissue sarcoma.



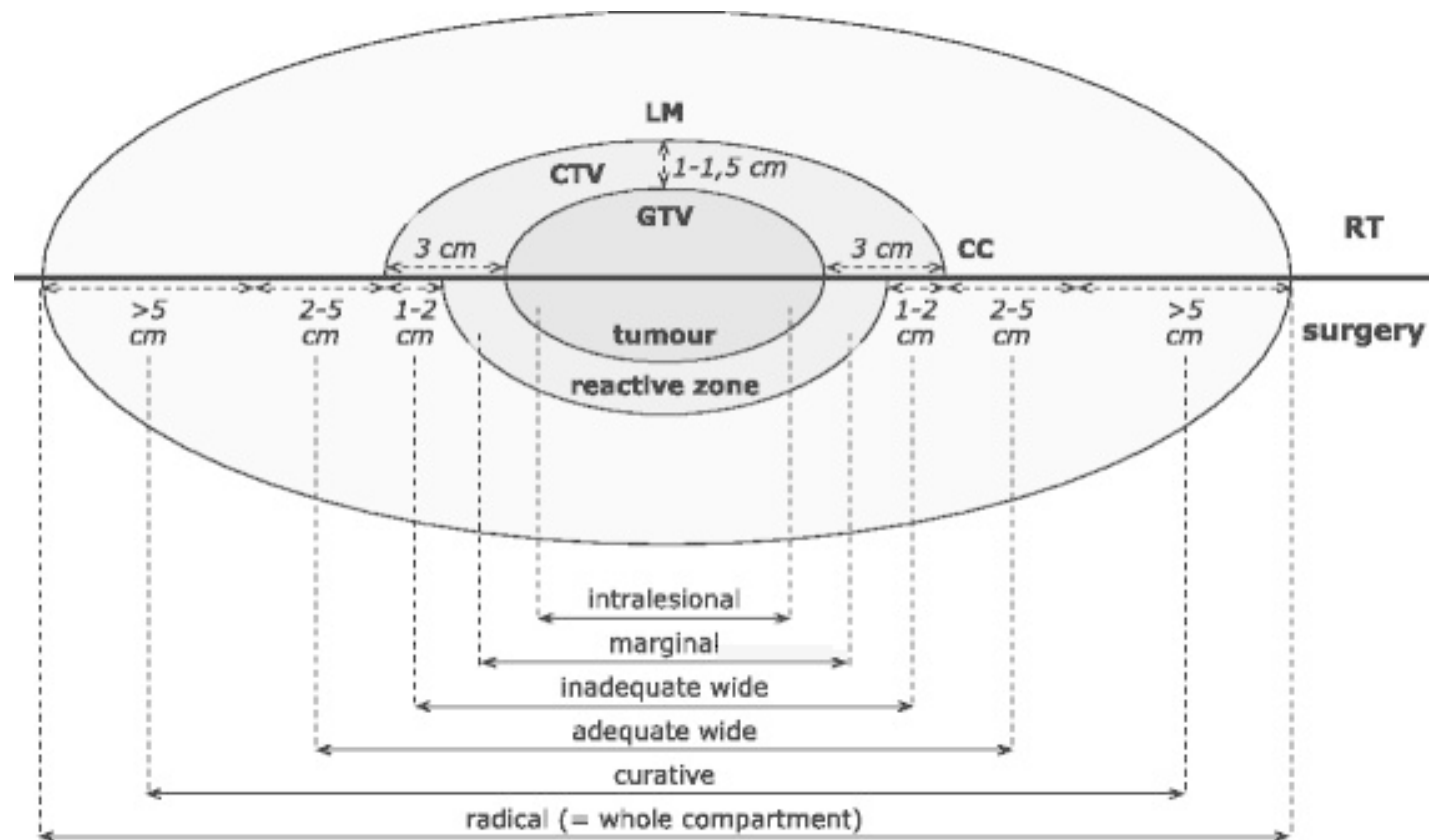
Sargos P, et al. Pre- and postoperative radiotherapy for extremity soft tissue sarcoma: Evaluation of inter-observer target volume contouring variability among French sarcoma group radiation oncologists. *Cancer Radiother* 2018;22(2):131-9.

Postoperative radiotherapy

- After limb-concerning surgery (removal of the tumor mass with a narrow excision margin $<1\text{cm}$) or due to microscopic residual disease (R1)
- Macroscopic residual disease (R2)
- Grade 2 or 3 histology
- Tumor size $\geq 5\text{cm}$
- All tumors of the head and neck region (due to the impossibility of adequate excision)
- Applying a dose $> 64\text{ Gy}$

Shrinking field

- **In the first phase**, a dose of about 45 Gy is applied to the expanded target volume (PTV1).
- **In the second phase**, an additional 10 to 15 Gy is applied to the reduced target volume (PTV2).
- **In the third phase**, the tumor bed (PTV3) is irradiated with a boost dose of 6 to 10 Gy



Hoefkens F, et al. Soft tissue sarcoma of the extremities: pending questions on surgery and radiotherapy. Radiat Oncol 2016;11(1):136.

Radical (definitive) radiotherapy

- Surgery is contraindicated
- Unresectable tumors
- The patient refuses surgery
- Inaccessible localization
- With or without HT

I Wide volume 50 Gy

II Boost volume 10-16 Gy

Intraoperative radiotherapy

- An essential device in the operating room
- Educated radiation oncologist and surgeon
- Irradiation of the tumor bed in one fraction
- A dose of 10 to 15 Gy is applied to the tumor bed with electrons

Dose prescription and fractionation regimens

Radical or adjuvant RT: Phase 1 (25 x 1.8-2 Gy)

- GTV1 - Tumor / tumor bed on pre-therapy CT/MRI/PET imaging
- CTV1 - GTV + 50 mm (low and moderate grade SMT) or GTV + 70 mm (high grade SMT)
- PTV1 - CTV + 5-10 mm (depending on the IGRT method and tumor localization)

Radical or adjuvant RT: Phase 2 (R1: 16-18 Gy; R2: 20-26 Gy)

- GTV2 - Tumor / tumor bed on pre-therapy CT/MRI/PET imaging
- CTV2 - GTV + 20 mm
- PTV2 - CTV2 + 5-10 mm (depending on the IGRT method)

Radical or adjuvant RT (optional): Phase 3 (boost: 6-10 Gy)

- PTV3 - GTV2 + 5-10 mm (depending on the IGRT method)

Preoperative radiotherapy

- Neoadjuvant RT (25 x 1.8-2 Gy)
 - GTV - Tumor on pre-therapy CT/MRI/PET imaging
 - CTV - GTV + 20 mm
 - PTV - CTV + 5-10 mm (depending on the IGRT method and tumor localization)
-
- R1 – boost dose to the tumor bed of 16 to 18 Gy
 - R2 - boost dose from 20 to 26 Gy

Interstitial brachytherapy

- Monotherapy or in combination with surgery
- Intraoperative or perioperative (HDR interstitial brachytherapy, 36 Gy in 10 fractions)
- Postoperative interstitial brachytherapy with TD 14-24 Gy + EBRT with TD 50 Gy

THANK YOU FOR YOUR ATTENTION!

