



ACIBADEM

# MR TABANLI TEDAVİLER: BİZE NE KAZANDIRDI?

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 **14. TÜRK MEDİKAL RADYOTEKNOLOJİ DERNEĞİ**  
**14. ULUSLARARASI KATILIMLI RADYOTEKNOLOJİ**  
**KONGRESİ VE EĞİTİM SEMİNERLERİ**

 **2. RADYOTERAPİ TEKNİKLERİ DERNEĞİ**  
**2. ULUSLARARASI KATILIMLI RADYOTERAPİ**  
**KONGRESİ VE EĞİTİM SEMİNERLERİ**

**"TANI, TEŞHİS, TEDAVİ BİR ARADA"**

21-24 Nisan 2019, Antalya  
Papillon Zeugma Relaxury Hotel



# MR Kılavuzluğunda Tedavilerin getirdiği avantajlar

1. Görüntüleme
2. Adaptif Plan
3. Tümör takibi



# IGRT Yöntemleri



MV EPID



kV Fluoroscopy + markers



Ultrasound



kV CT



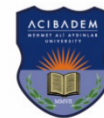
MV CT



MV cone  
beam CT



kV Cone-beam CT



# IGRT Yöntemleri



MV EPID

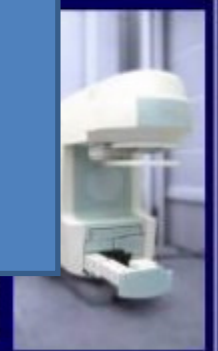


kV CT



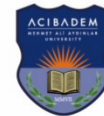
MV CT

MV cone  
beam CT

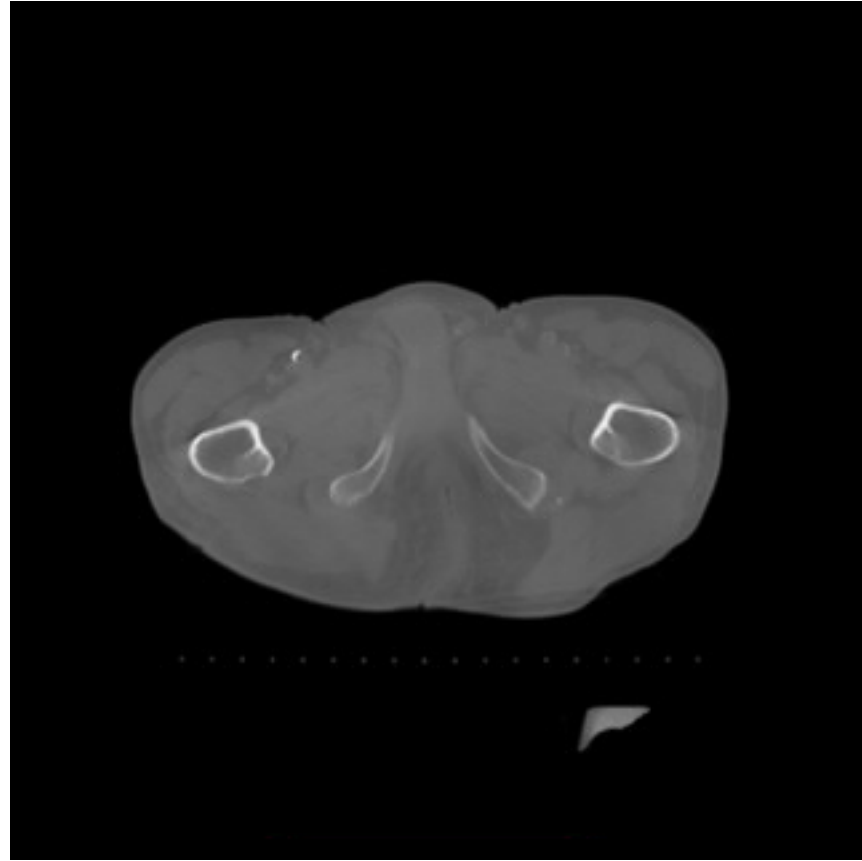


kV Cone-beam CT

Çoğunlukla X-ışını tabanlı  
Yumuşak dokular için  
suboptimal

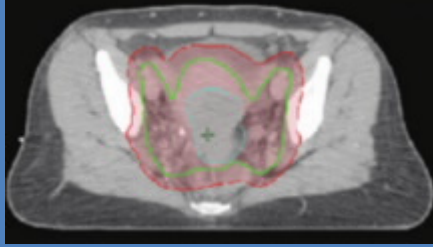


MR öncesi en iyi IGRT yöntemi...



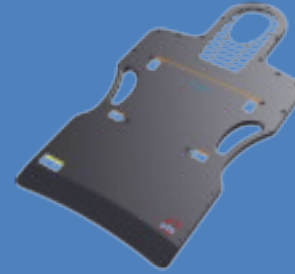
# Hedefi tam görememenin telafisi

Sa lı blokuyu  
içeren marjinler  
verilmesi



Tümörün  
yerle imini  
tahmin etmek  
için marker'lar

Tedavi sı rası nda  
hastanı n  
pozisyonunu ve  
hareketini takip  
etmek için  
eksternal  
sistemler



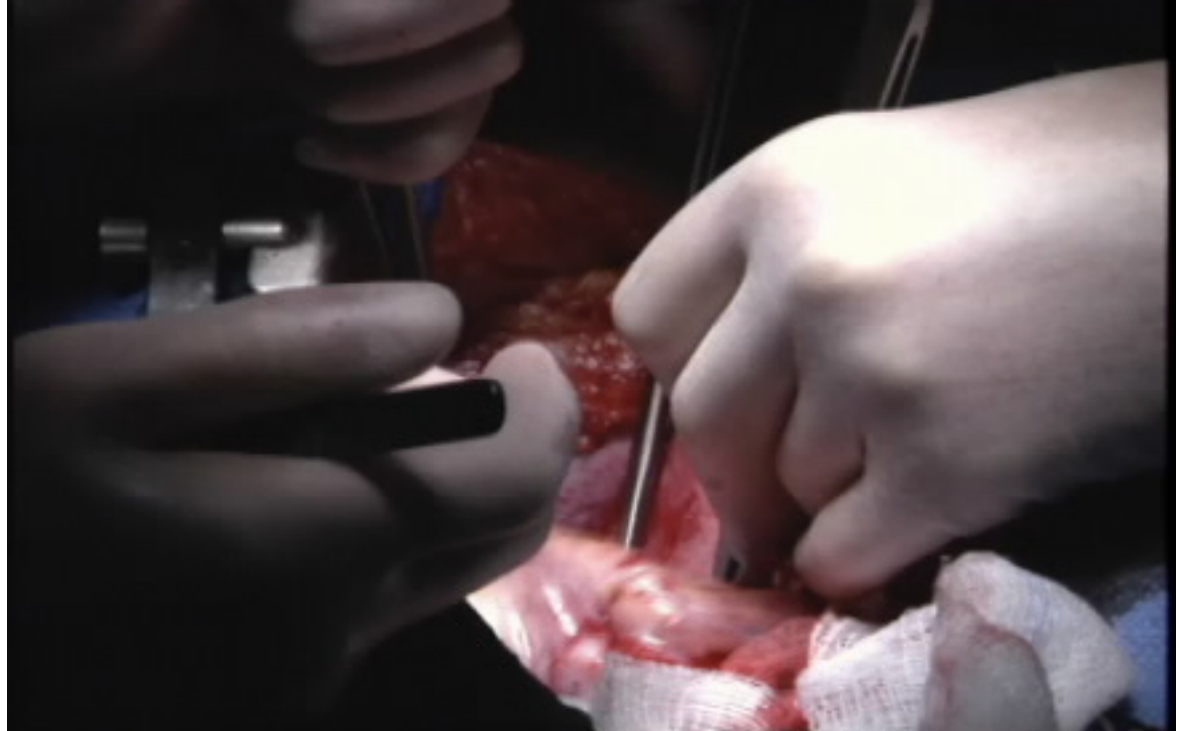
mmbolizasyon  
için fiksasyon  
cihazları

# GÖRMEK !!!

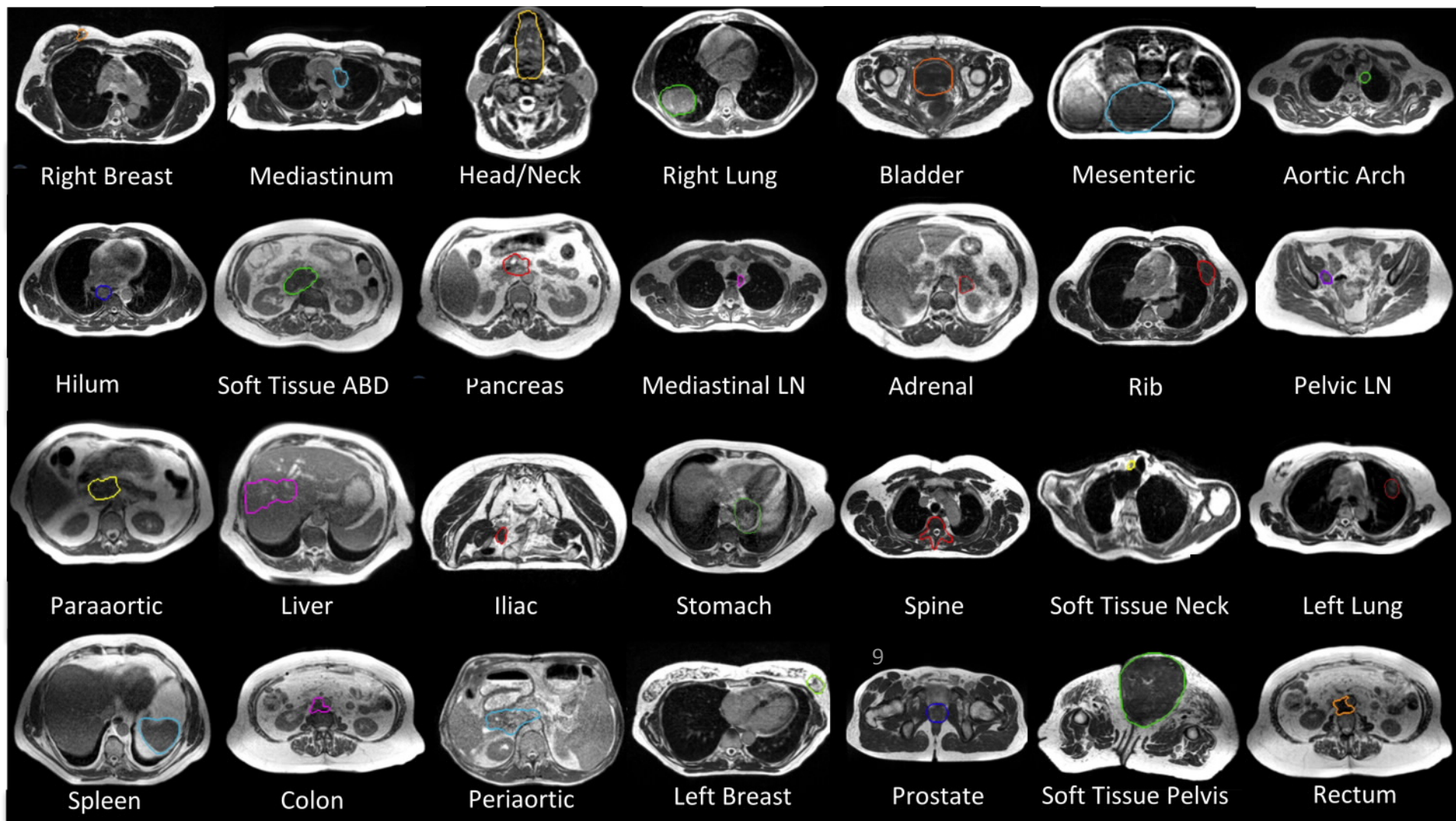
## CERRAHLARIN AVANTAJI

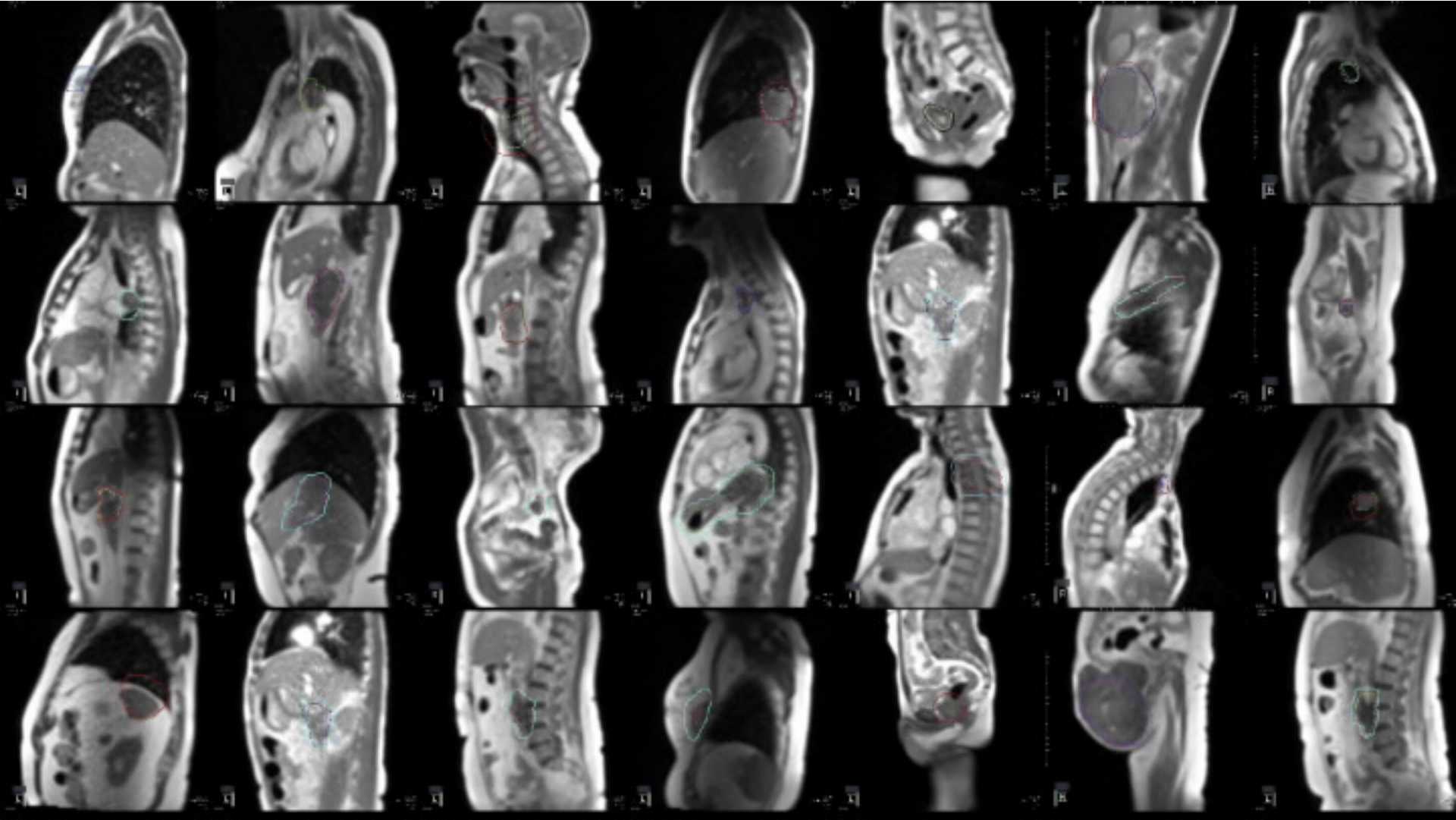
Surgeons cut open patients and see all of the motion and treat around it.

**MRIdian LINAC** brings real-time MRI vision to Radiation Medicine.









# Stereotaktik Radioterapi

Kolay



Brain tumors  
Head & Neck Tumors  
Peripheral lung  
Bone mets

Zor



Liver mets / HCC  
Prostate cancer  
Tumors close to  
diaphragm/heart  
Adrenal tumors/mets

Çok zor



Pancreas  
Biliary track tumors  
Liver mets/HCC  
Central lung  
Kidney tumors

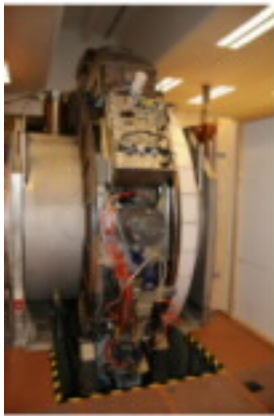
# MRG Linac Tarihi

(collaboration UMCU, Elekta and Philips)

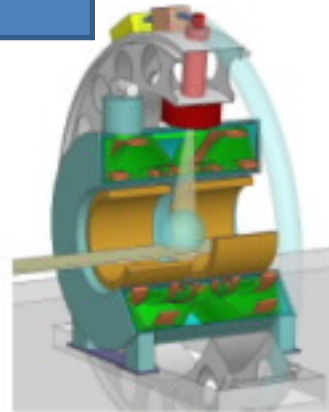
Radiotherapy and Oncology. Vol 56, Sup 1, Pages S1-S255, 2000, 19th Annual ESTRO Meeting Istanbul, Turkey

MRI guided radiotherapy: a MRI based linear accelerator. J.J.W. Lagendijk, C.J.G. Bakker

1999  
invention



2012  
2<sup>nd</sup> prototype



2004  
design



2009  
1<sup>st</sup> prototype



2015  
Clinical grade prototype



2016  
Clinical prototype



# VIEWRAY Tarihçesi

MR+RT  
DEVICE  
INVENTION  
DISCLOSED  
2003



FIRST  
PROTOTYPE  
BUILT  
2010

CLINICAL  
RESEARCH  
BEGINS AT  
WASHINGTON  
UNIVERSITY  
2012

FIRST  
PATIENT  
TREATED  
2014

CE MARK  
FOR  
MRIDIAN  
LINAC  
2016

FIRST LINAC  
PATIENT  
TREATED  
2017



2004  
VIEWRAY  
FOUNDED

2011  
FDA CLEARANCE  
FOR TPS AND  
DELIVERY SW

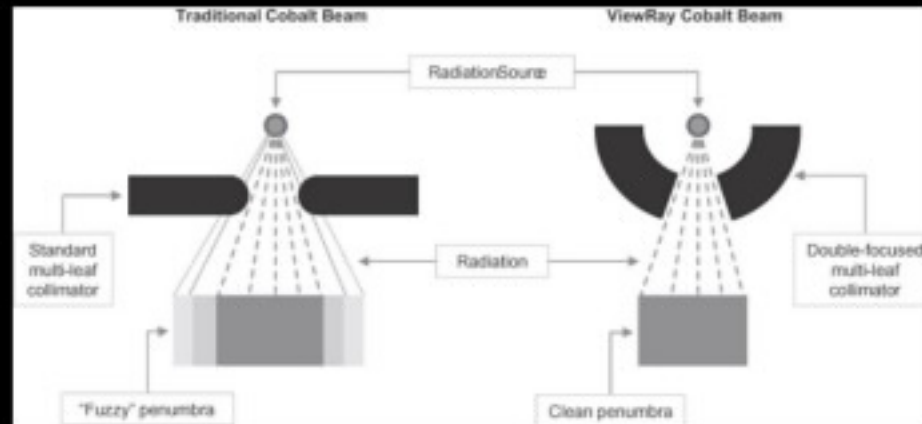
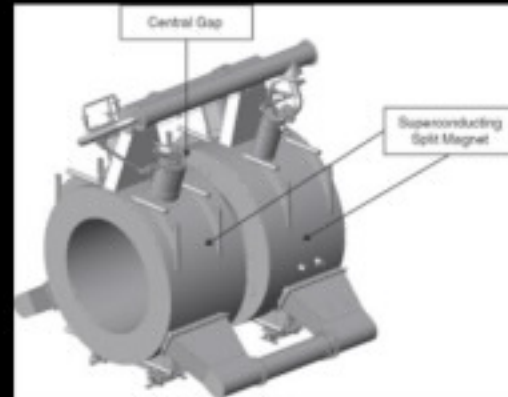
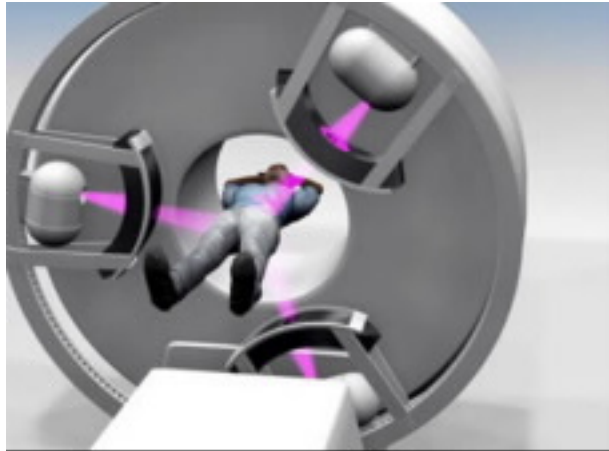
2012  
FDA CLEARANCE  
FOR  
MRIDIAN

2014  
FIRST  
ON TABLE  
ADAPTIVE RT

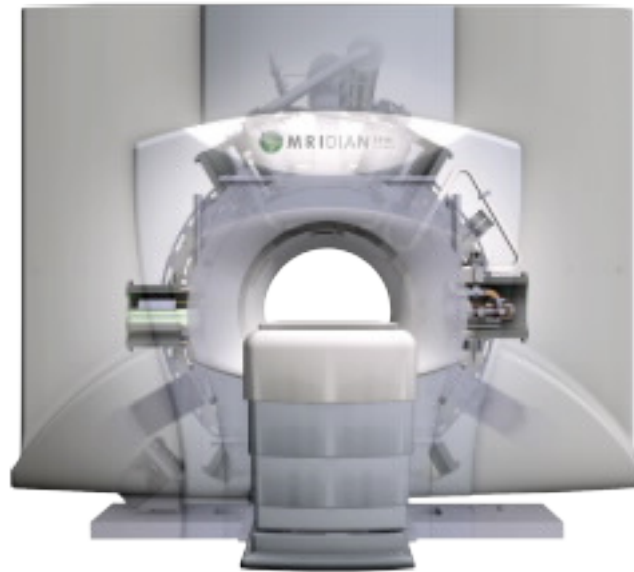
2017  
FDA CLEARANCE  
FOR  
MRIDIAN LINAC



# MR-guided RT System: MRIdian



# The MRIdian LINAC System



## MRI

- 0.35 T
- 70 cm bore
- 50 cm FOV
- Real-time imaging 8 FPS

## RT

- 6 MV FFF
- >600cGy/min
- Double-Focused  
Double Stacked
- Tx =27cmx24cm

## TPS

- Monte Carlo
- Very fast
- Online ART

# ViewRay MR LINACs

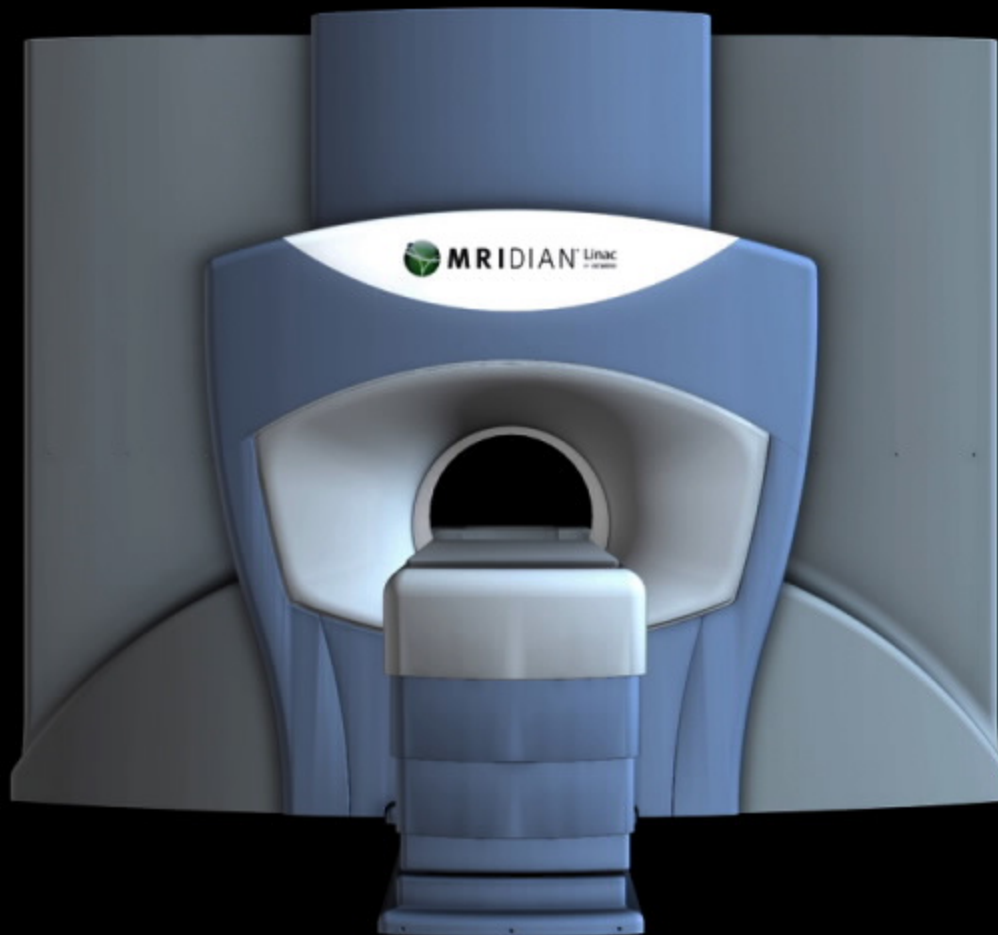






İlk hasta alımı 10 Eylül 2018

COMPACT  
6 MV LINAC

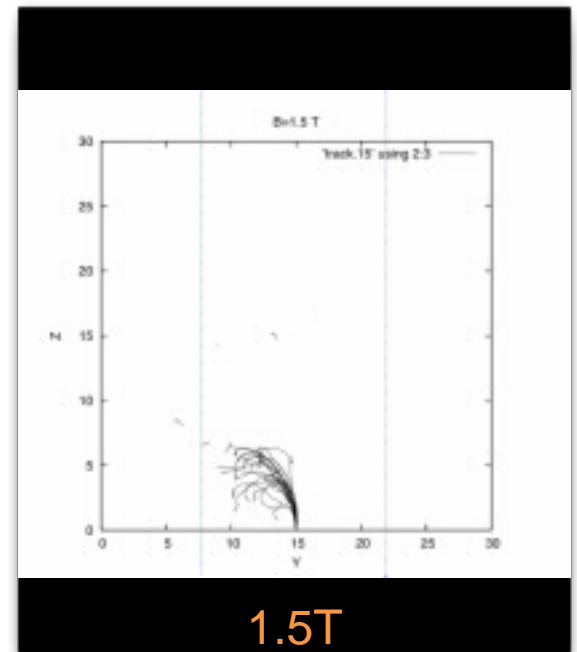
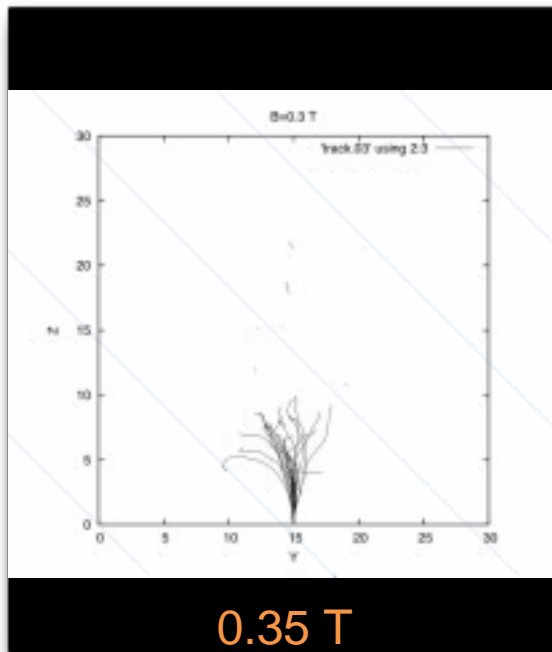
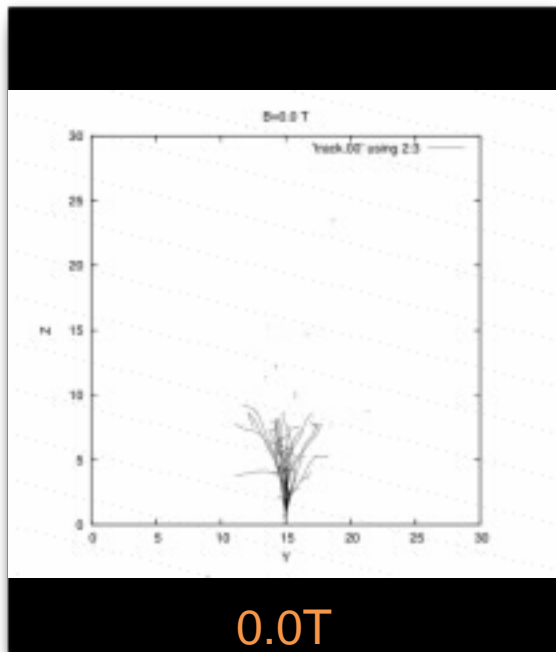




\*SmartVISION™ is 510(k) pending clearance and not available for sale.

# Bigger is Not Always Better: 0.35 T vs 1.5 T

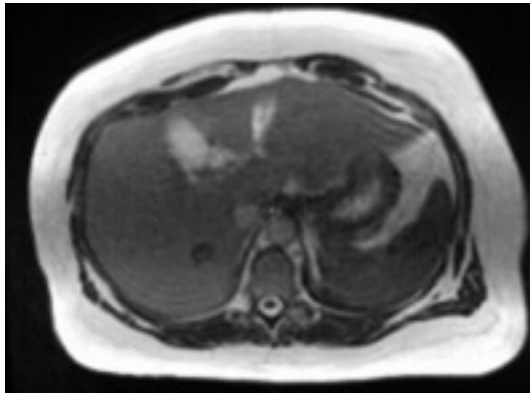
Electron Return Effect Increases with Magnetic Field



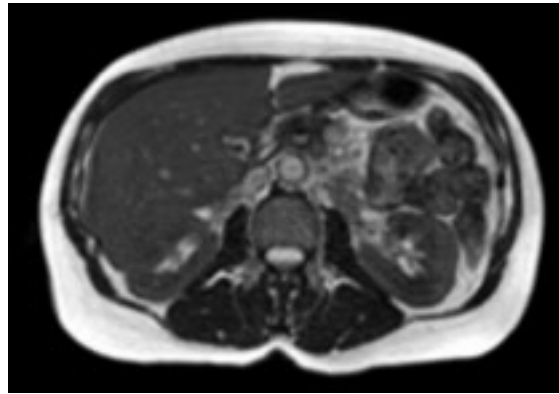
Electron Return Effect: return of electrons to the tissue at the beam exit point, leading to increased dose

# Görüntüleme Kalitesi 0.35 T

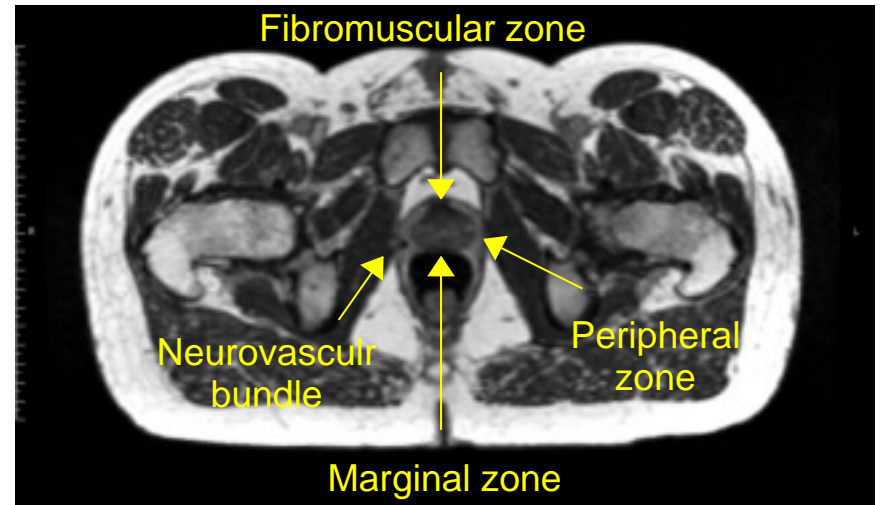
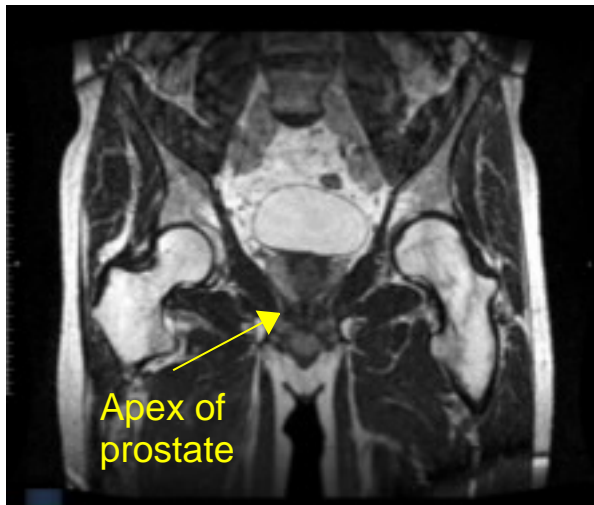
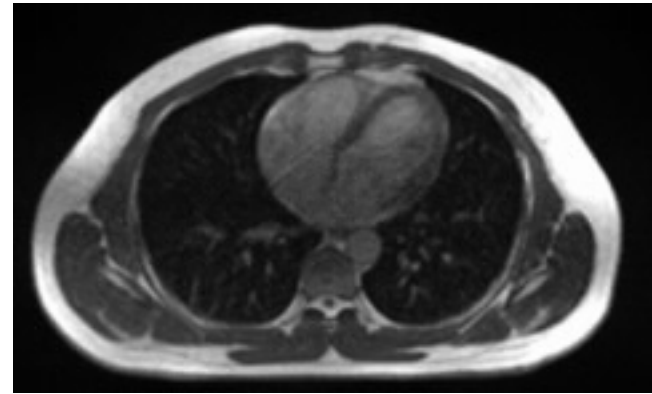
Liver



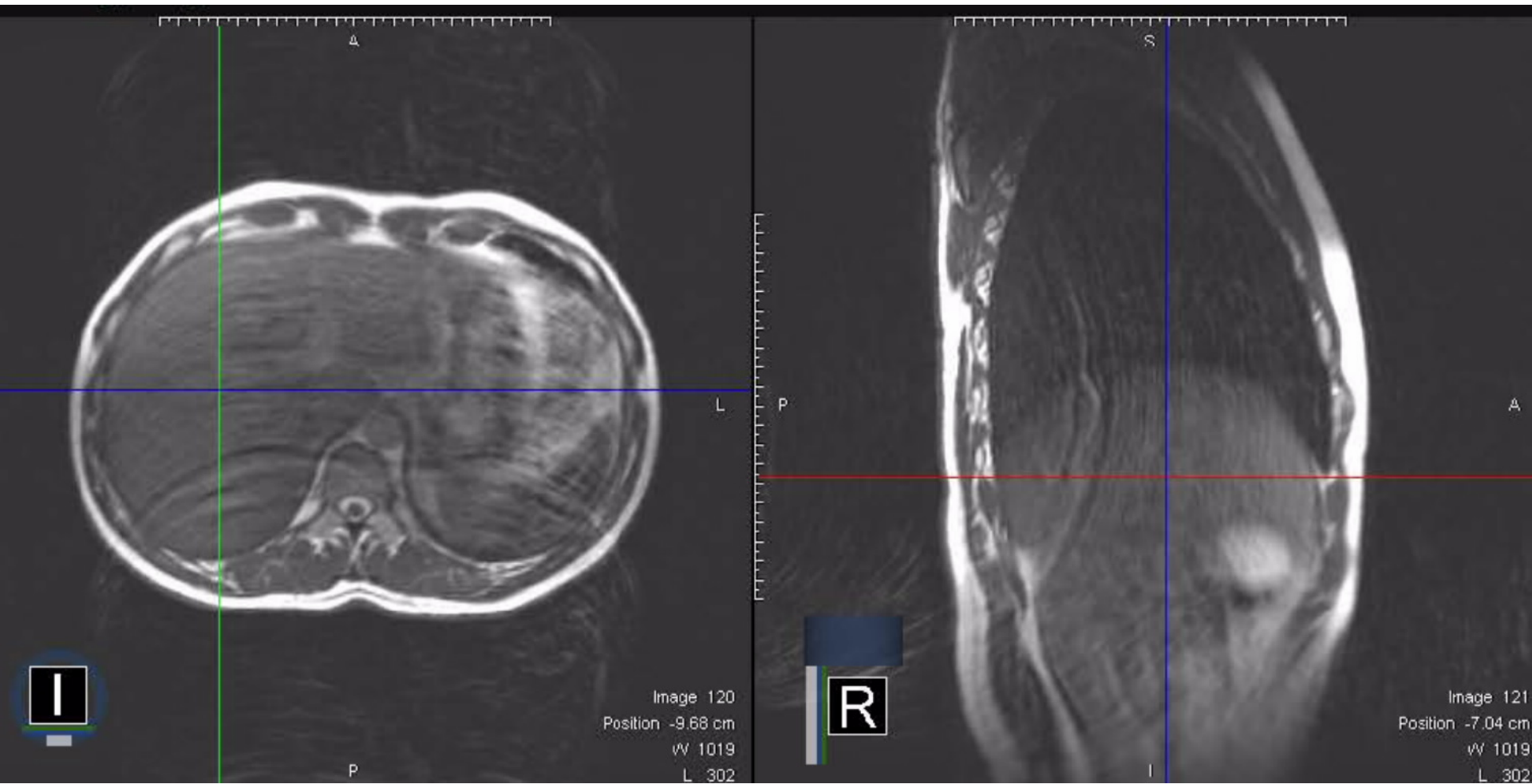
Pancreas

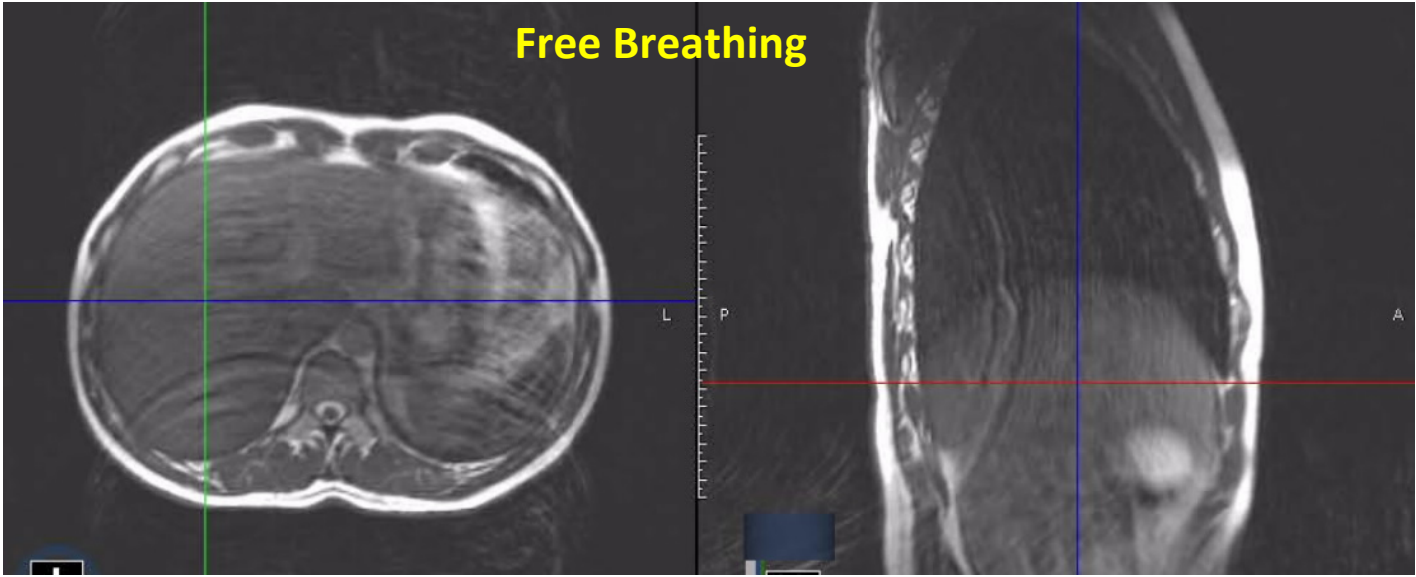
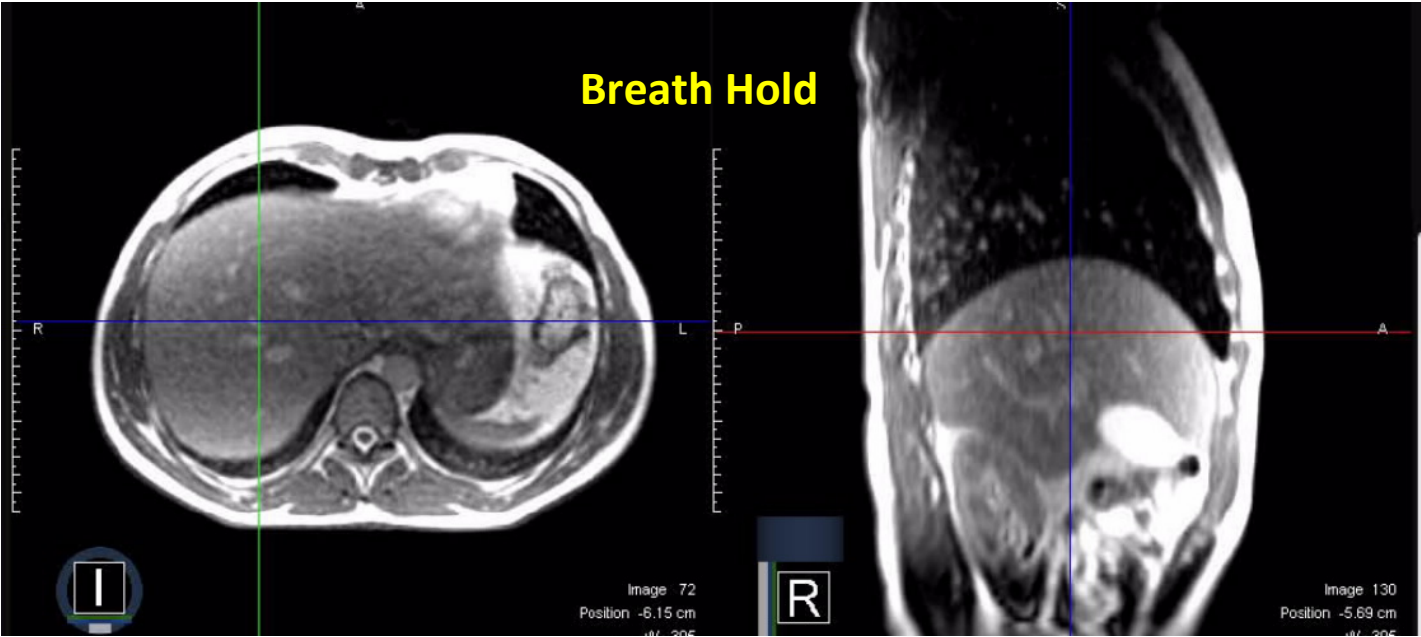


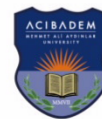
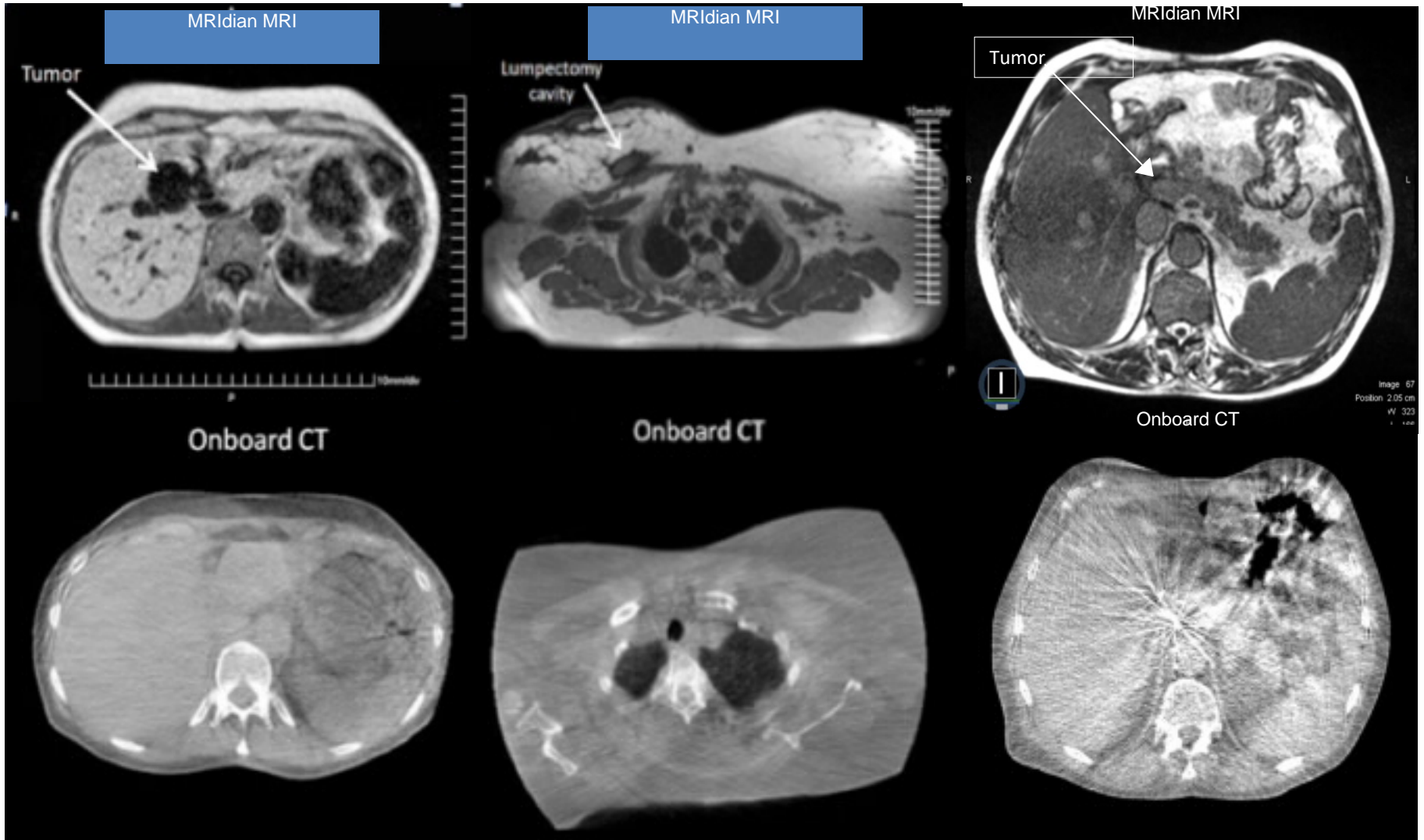
Lung



# Serbest Solunum ile MR görüntüleme









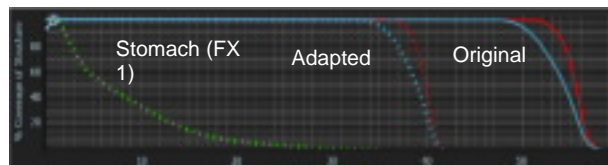
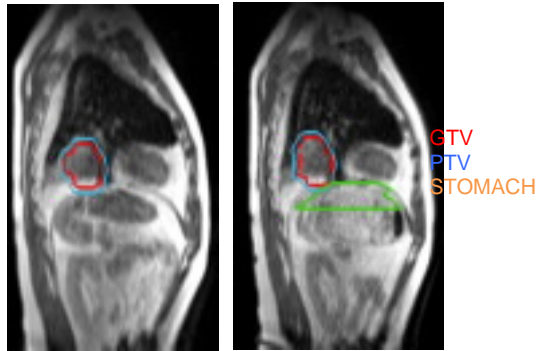
# Here's how MRIdian<sup>®</sup> Vision makes a difference

MRIdian – MRI based setup



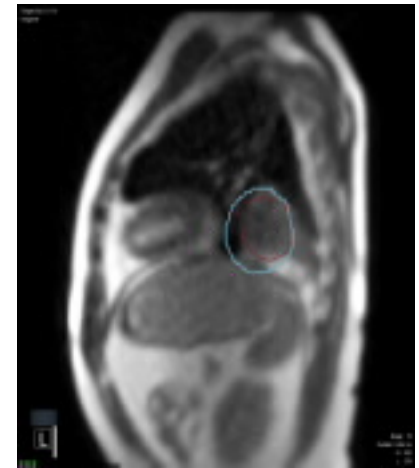
Most accurate soft tissue alignment today

MRIdian<sup>®</sup> - MRI guided On-table Adapting



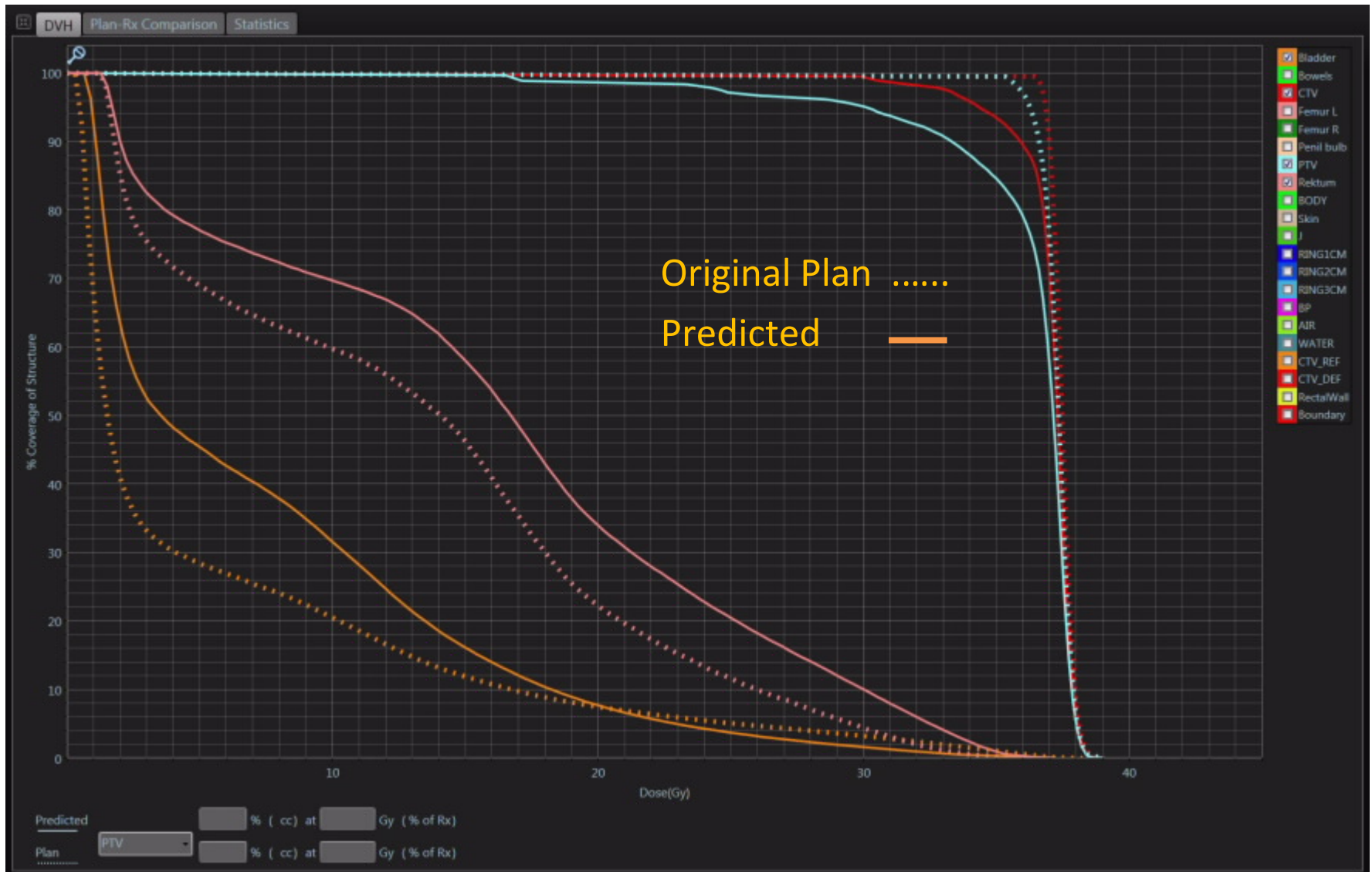
Make changes to match daily soft tissue anatomy

MRIdian<sup>®</sup> - MRI based tracking

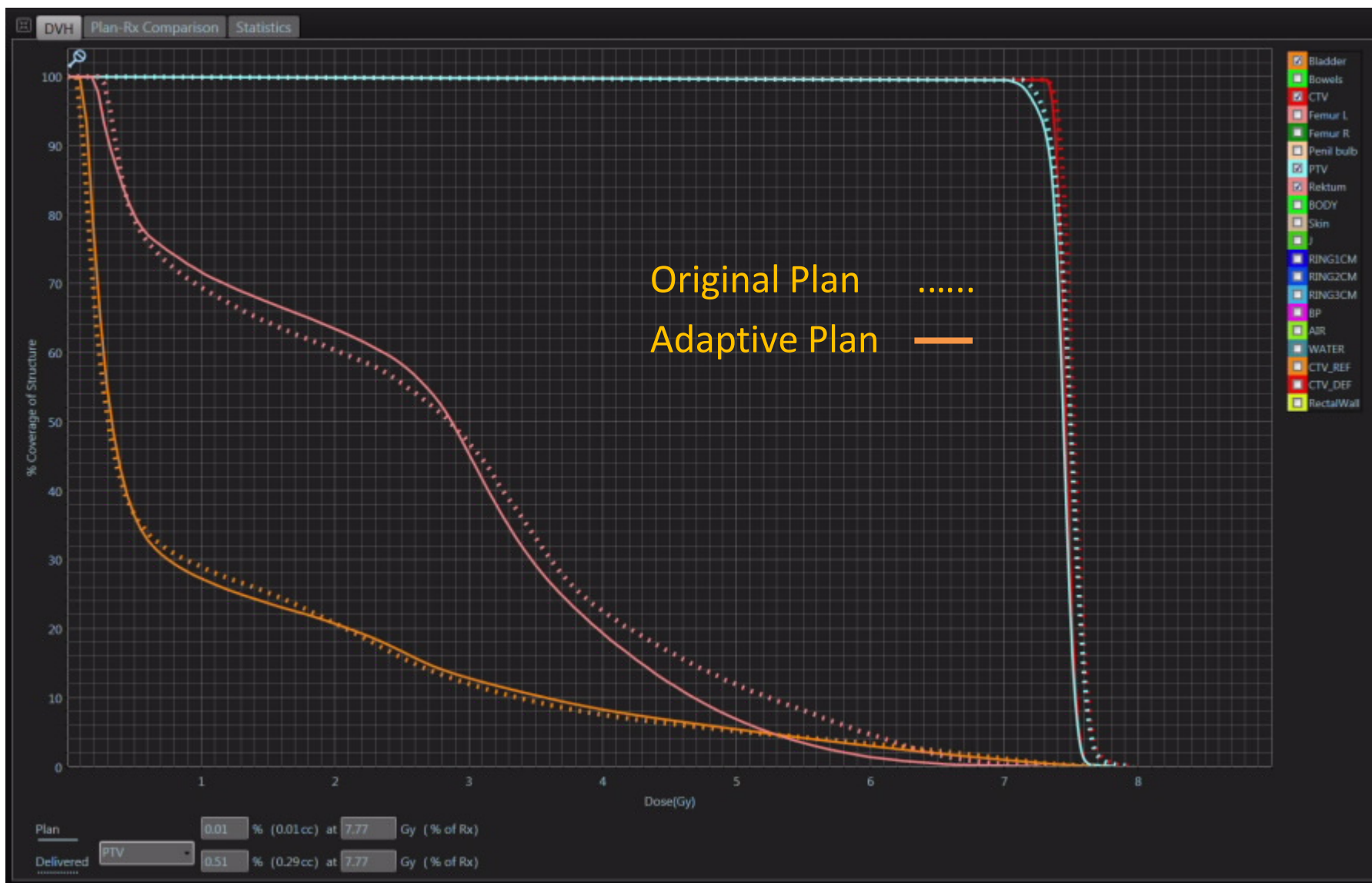


See what you treat while you treat it

# Original Plan vs Predicted Plan w/o adaptation



# Adaptive Plan vs Original Plan



# OAR and Coverage violation Decision for ADAPTIVE PLAN

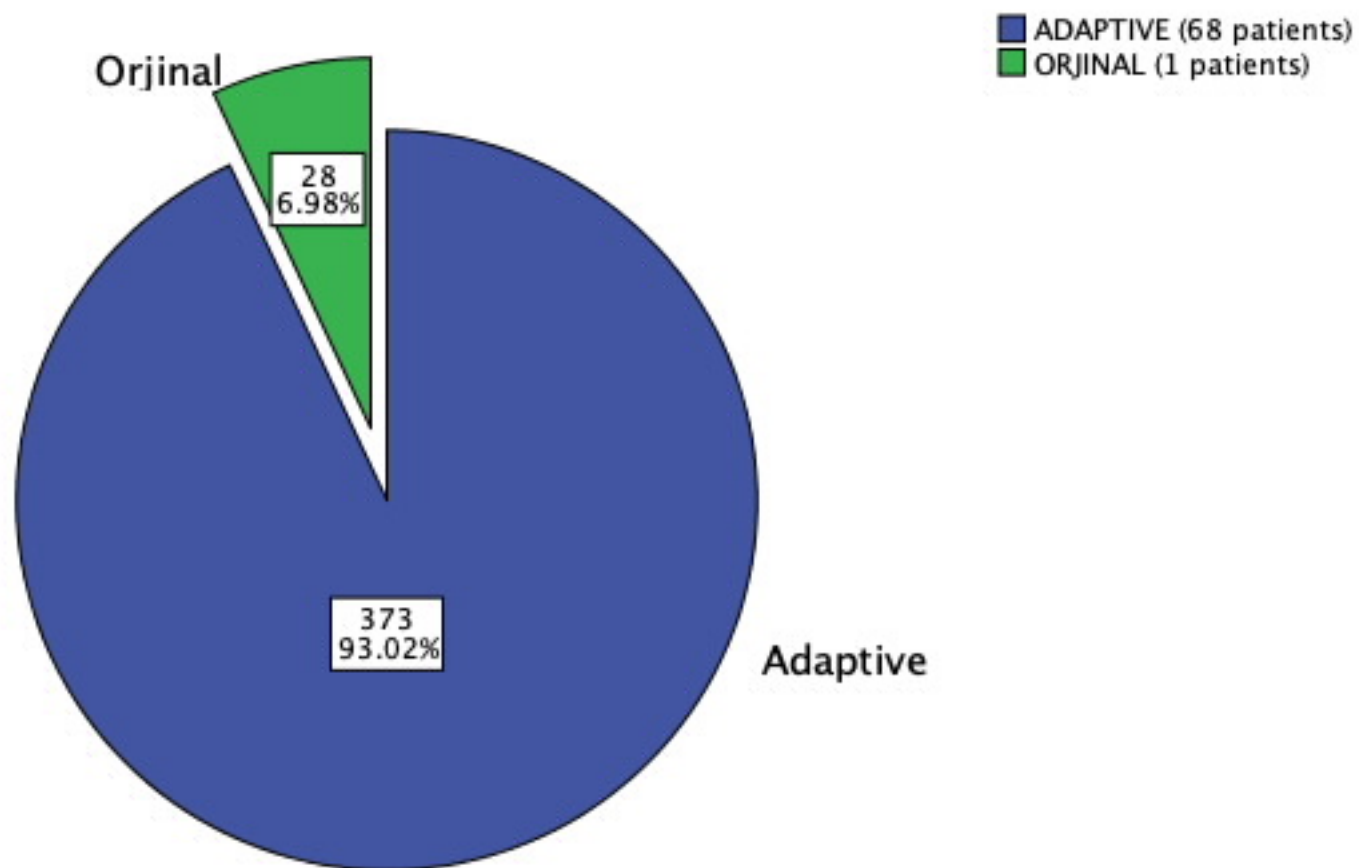
# Reoptimization After ADAPTIVE PLAN

Structure/Point	Min	Mean	Max	Dose to Volume		
PTV	Rx			>= 95	% at 36.25	Gy
	Predicted	14.91	36.06	38.99	76.49	% at 36.25 Gy
	Plan	33.98	37.27	39.05	95.00	% at 36.25 Gy
Rektum	Rx			< 1	% at 35	Gy
	Predicted	1.27	15.97	37.21	0.89	% at 35 Gy
	Plan	1.23	13.06	36.35	0.18	% at 35 Gy
Rektum	Rx			< 41	% at 17.5	Gy
	Predicted	1.27	15.97	37.21	45.68	% at 17.5 Gy
	Plan	1.23	13.06	36.35	32.60	% at 17.5 Gy
Rektum	Rx			< 35	% at 18	Gy
	Predicted	1.27	15.97	37.21	42.93	% at 18 Gy
	Plan	1.23	13.06	36.35	30.09	% at 18 Gy
Rektum	Rx			< 10	% at 28	Gy
	Predicted	1.27	15.97	37.21	14.03	% at 28 Gy
	Plan	1.23	13.06	36.35	7.09	% at 28 Gy
Rektum	Rx			< 5	% at 32	Gy
	Predicted	1.27	15.97	37.21	5.91	% at 32 Gy
	Plan	1.23	13.06	36.35	1.97	% at 32 Gy
Rektum	Rx			< 20	cc at 25	Gy
	Predicted	1.27	15.97	37.21	12.74	cc at 25 Gy
	Plan	1.23	13.06	36.35	7.95	cc at 25 Gy
Rektum	Rx			< 0.1	% at 38	Gy
	Predicted	1.27	15.97	37.21	0	% at 38 Gy
	Plan	1.23	13.06	36.35	0	% at 38 Gy
Bladder	Rx			< 43	% at 17.5	Gy

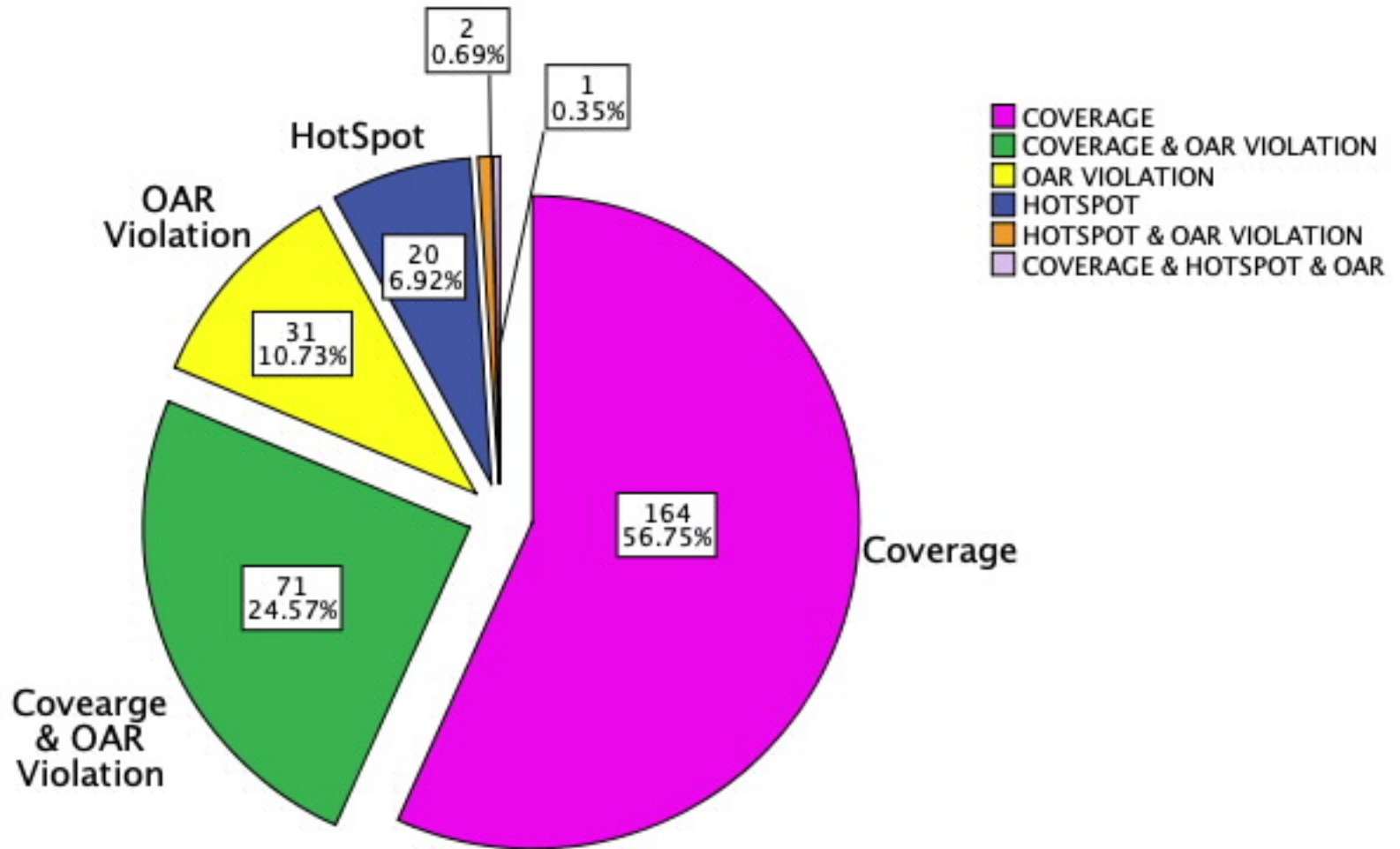


Structure/Point	Min	Mean	Max	Dose to Volume		
PTV	Rx			>= 95	% at 7.25	Gy
	Plan	6.52	7.43	7.82	95.00	% at 7.25 Gy
	Delivered	6.85	7.48	7.96	97.12	% at 7.25 Gy
Rektum	Rx			< 1	% at 7	Gy
	Plan	0.18	2.55	7.27	0.04	% at 7 Gy
	Delivered	0.23	2.64	7.33	0.33	% at 7 Gy
Rektum	Rx			< 41	% at 3.5	Gy
	Plan	0.18	2.55	7.27	29.12	% at 3.5 Gy
	Delivered	0.23	2.64	7.33	33.13	% at 3.5 Gy
Rektum	Rx			< 35	% at 3.6	Gy
	Plan	0.18	2.55	7.27	26.77	% at 3.6 Gy
	Delivered	0.23	2.64	7.33	30.34	% at 3.6 Gy
Rektum	Rx			< 10	% at 5.6	Gy
	Plan	0.18	2.55	7.27	2.86	% at 5.6 Gy
	Delivered	0.23	2.64	7.33	7.40	% at 5.6 Gy
Rektum	Rx			< 5	% at 6.4	Gy
	Plan	0.18	2.55	7.27	0.53	% at 6.4 Gy
	Delivered	0.23	2.64	7.33	2.23	% at 6.4 Gy
Rektum	Rx			< 20	cc at 5	Gy
	Plan	0.18	2.55	7.27	4.98	cc at 5 Gy
	Delivered	0.23	2.64	7.33	8.14	cc at 5 Gy
Rektum	Rx			< 0.1	% at 7.6	Gy
	Plan	0.18	2.55	7.27	0	% at 7.6 Gy
	Delivered	0.23	2.64	7.33	0	% at 7.6 Gy

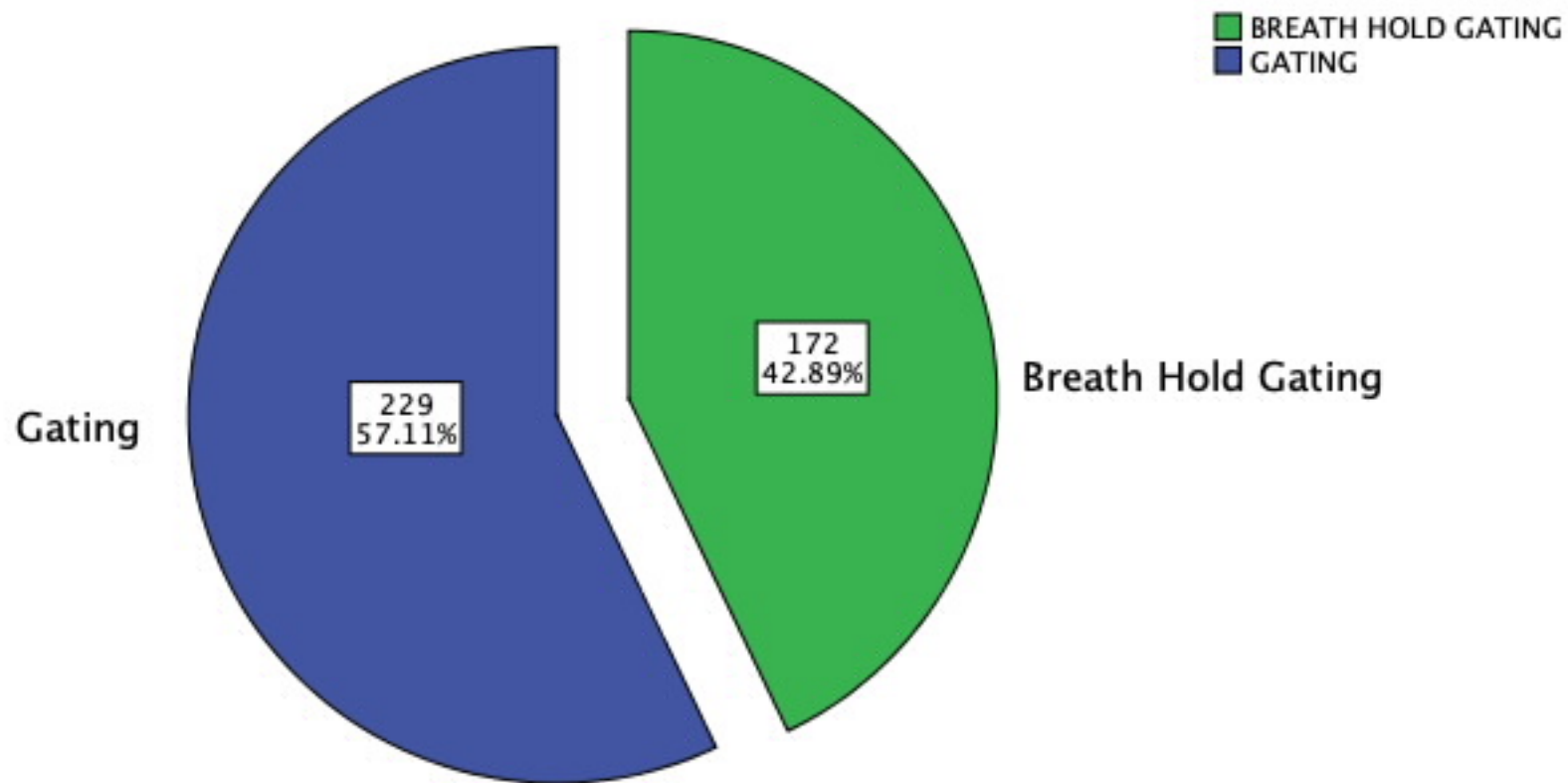
## TREATMENT APPROACH OF 401 FRACTIONS



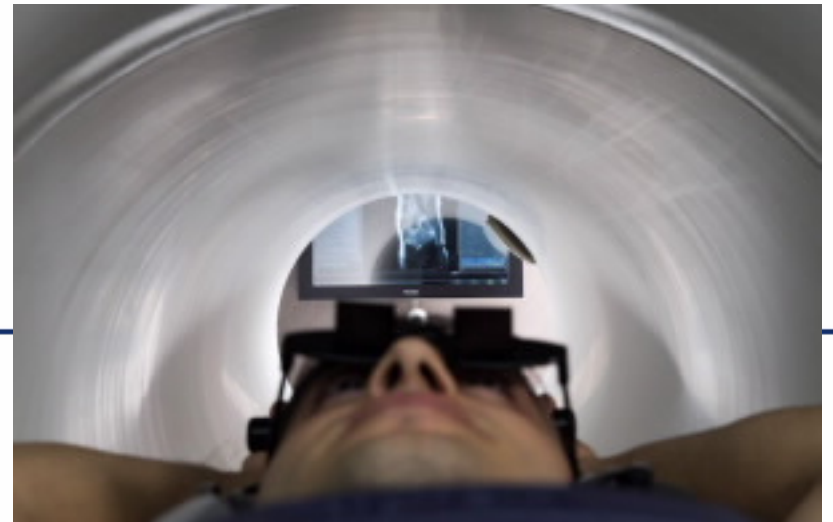
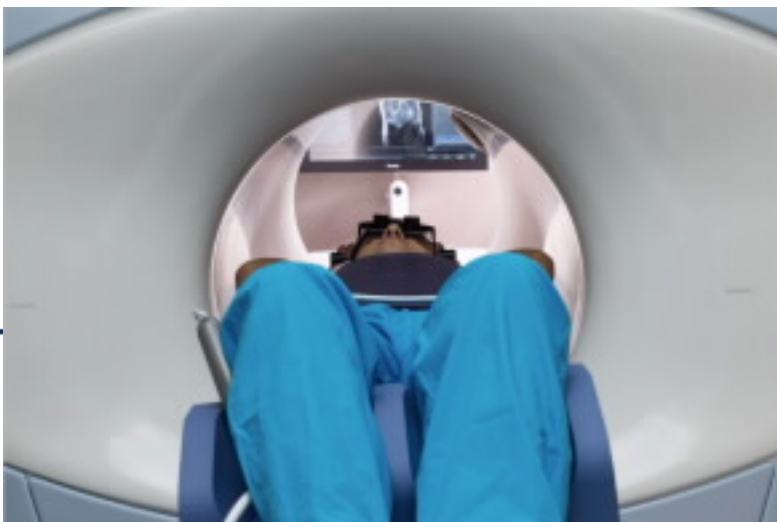
## REASONS OF ADAPTIVE PLAN APPROACH



# GATING DISTRIBUTION of 401 FRACTIONS



# Visual Coaching for Respiratory Gating





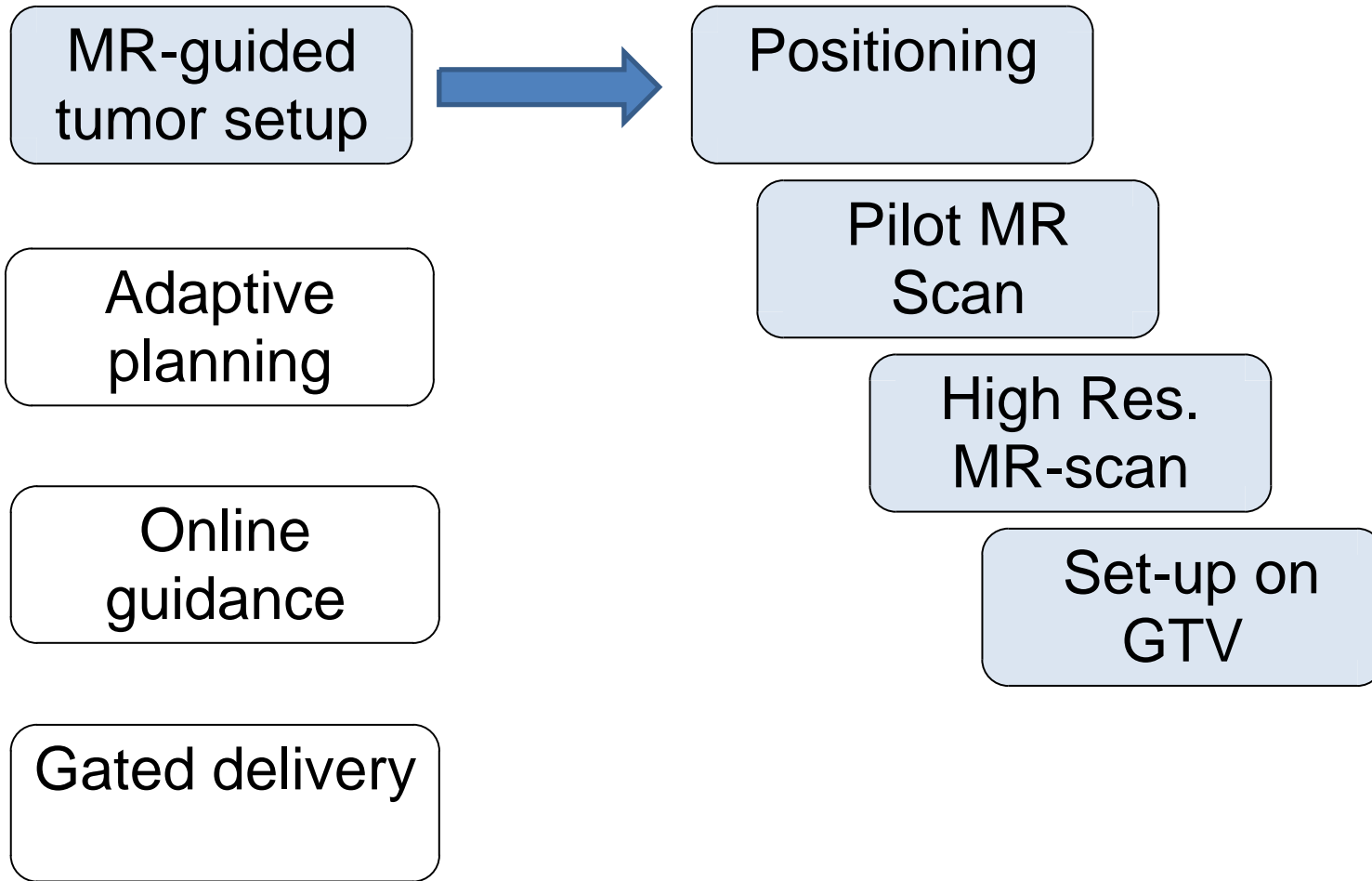
# MR-Guided Radiotherapy Daily Treatment Workflow

Align

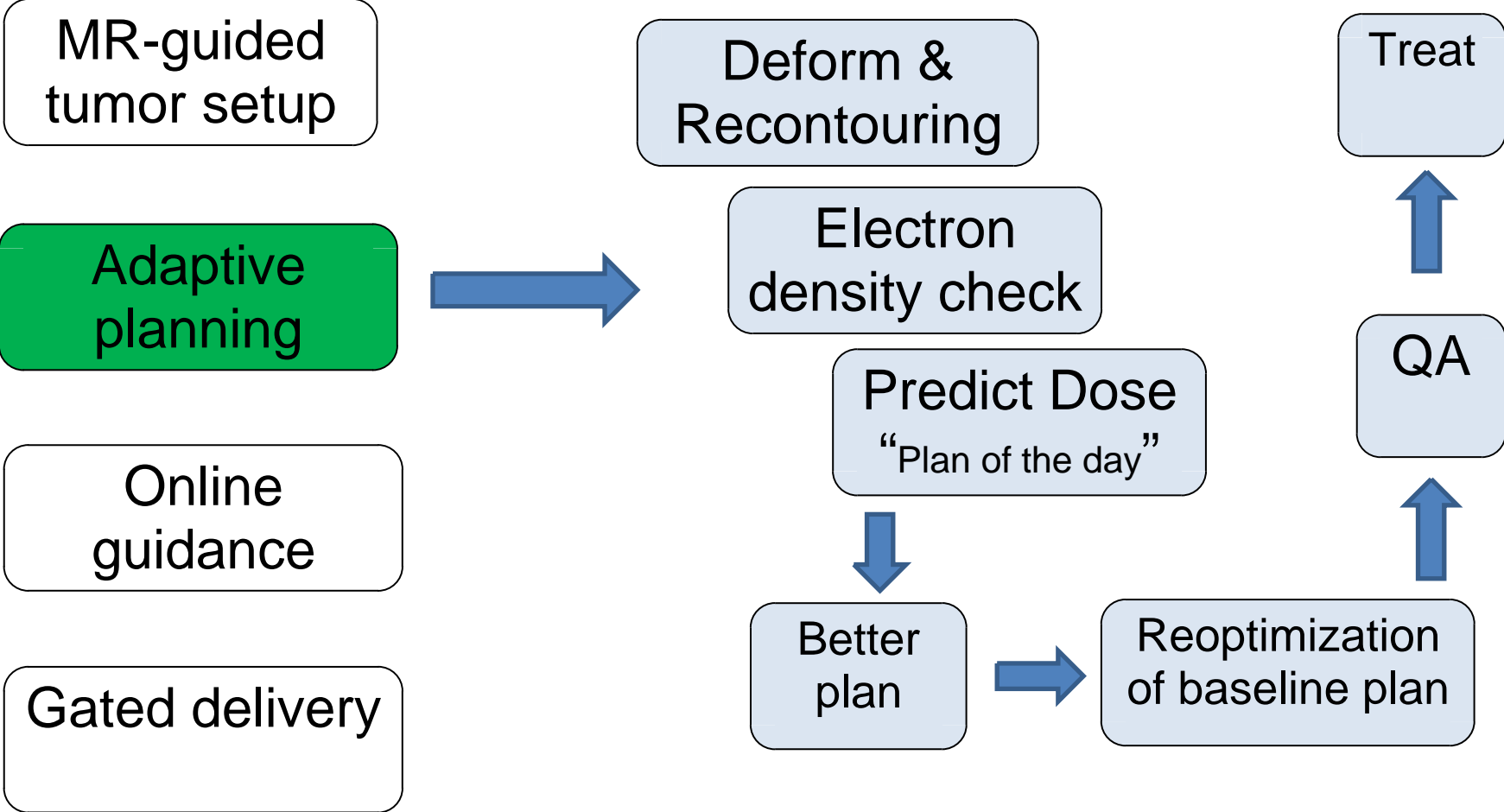
Adapt

Track

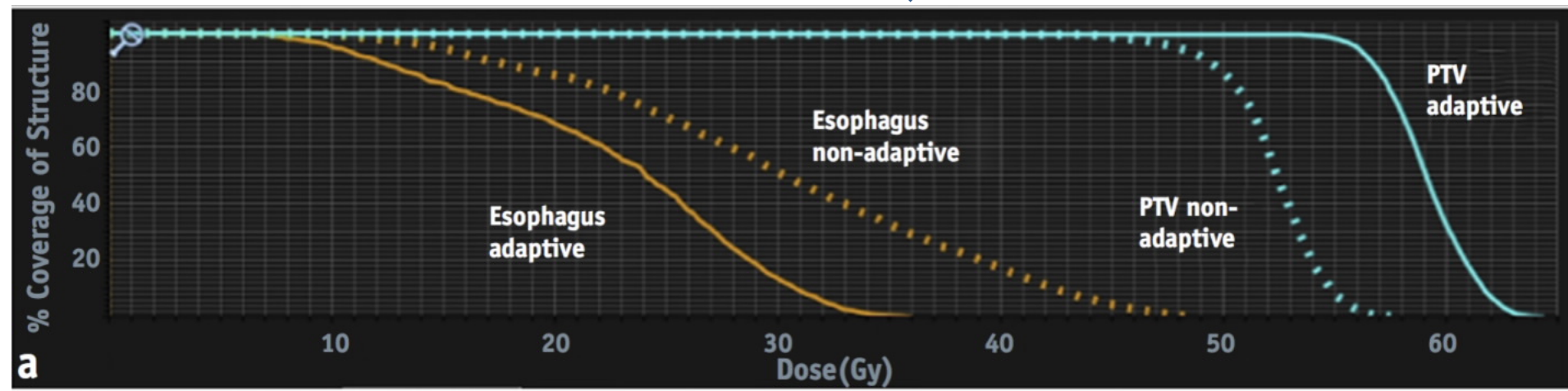
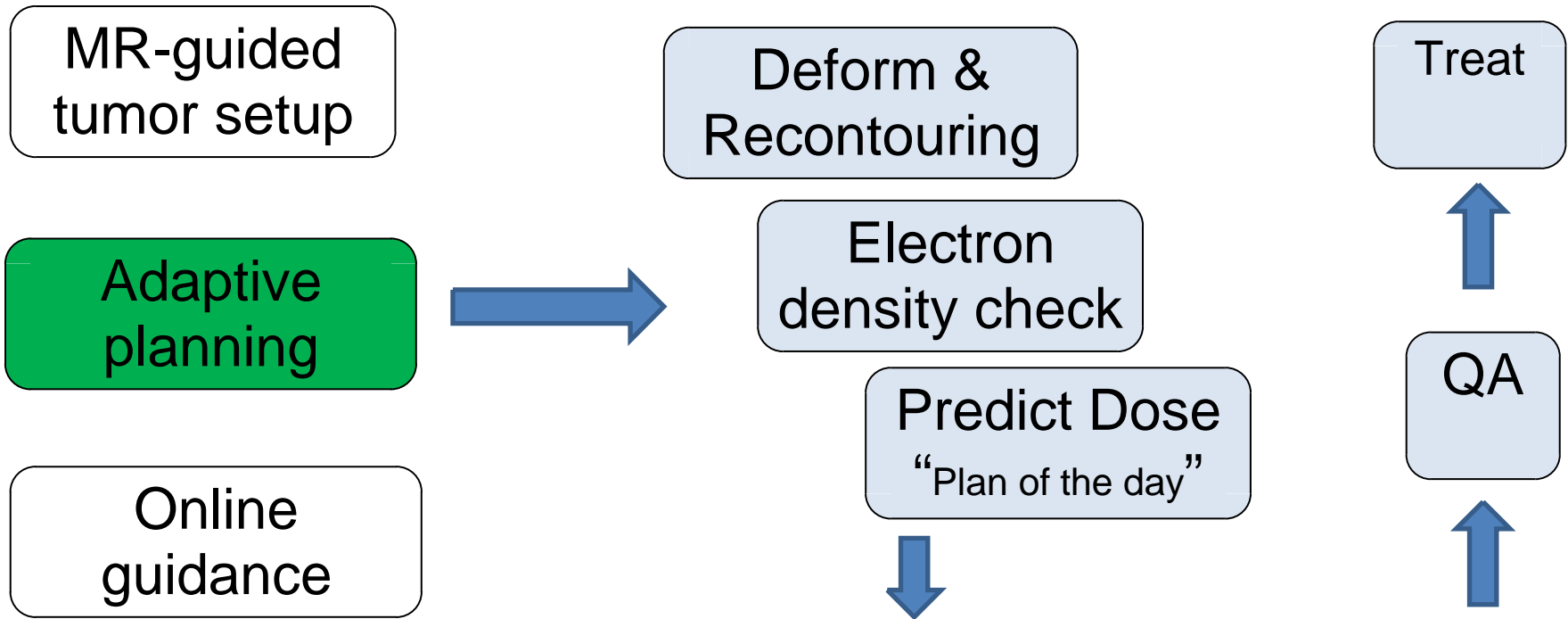
# MR-Guided Radiotherapy Workflow



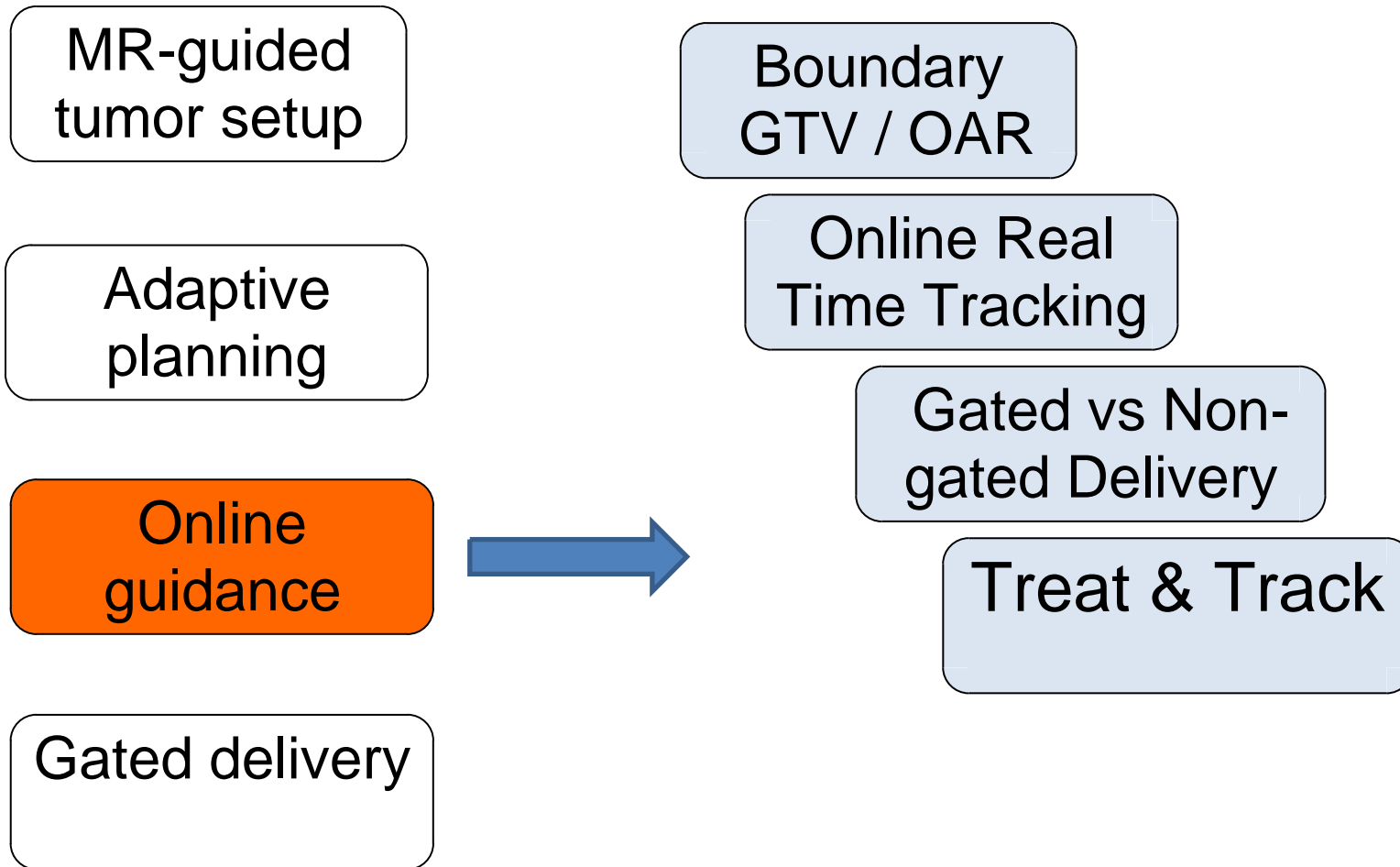
# MR-Guided Radiotherapy Workflow



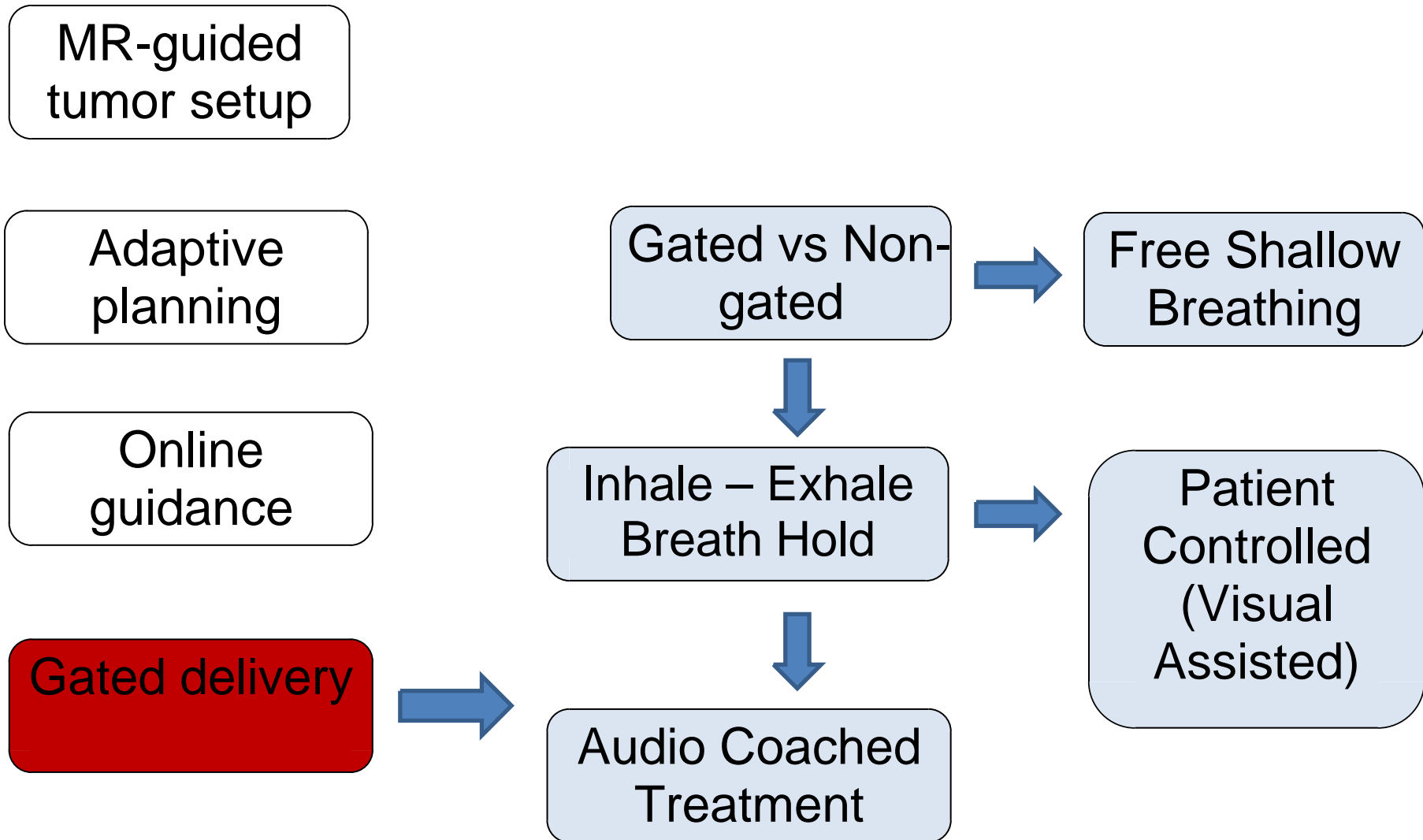
# MR-Guided Radiotherapy Workflow



# MR-Guided Radiotherapy Workflow



# MR-Guided Radiotherapy Workflow



# Adaptive Treatment Planning

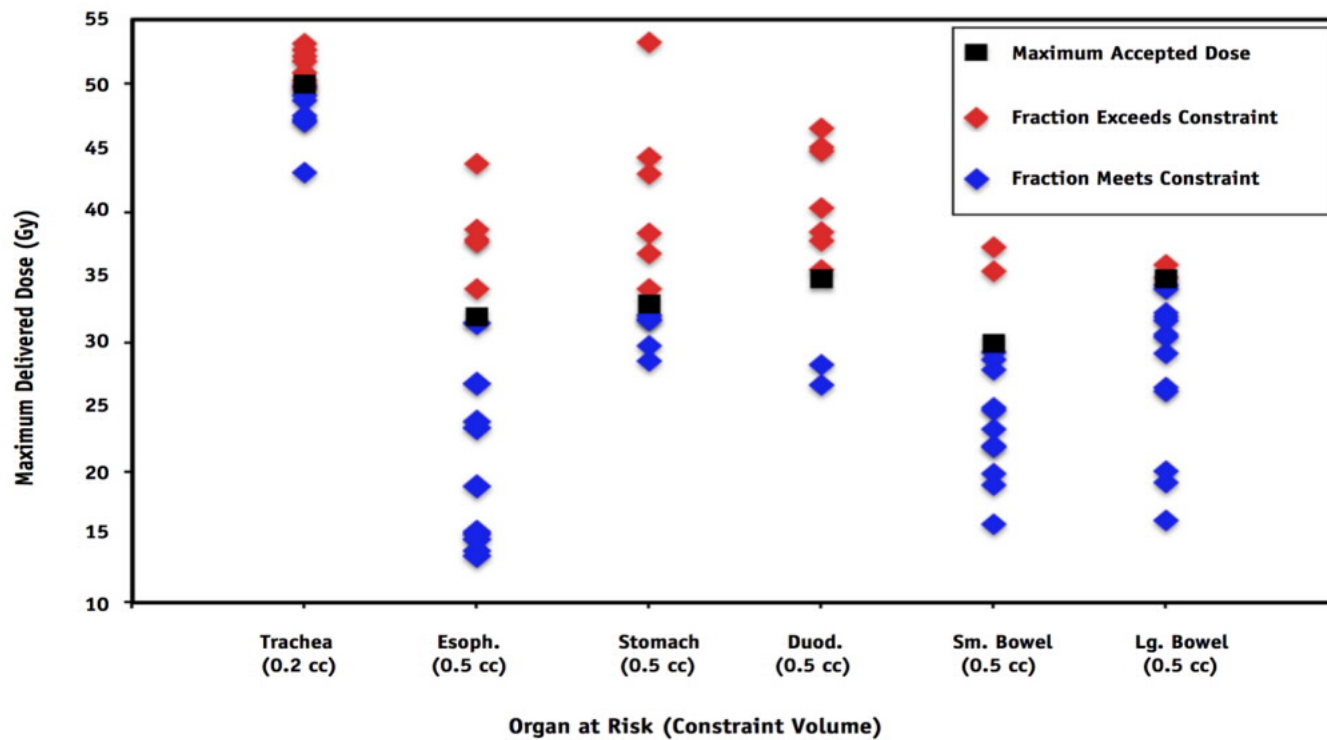
Original Plan

Day of Treatment

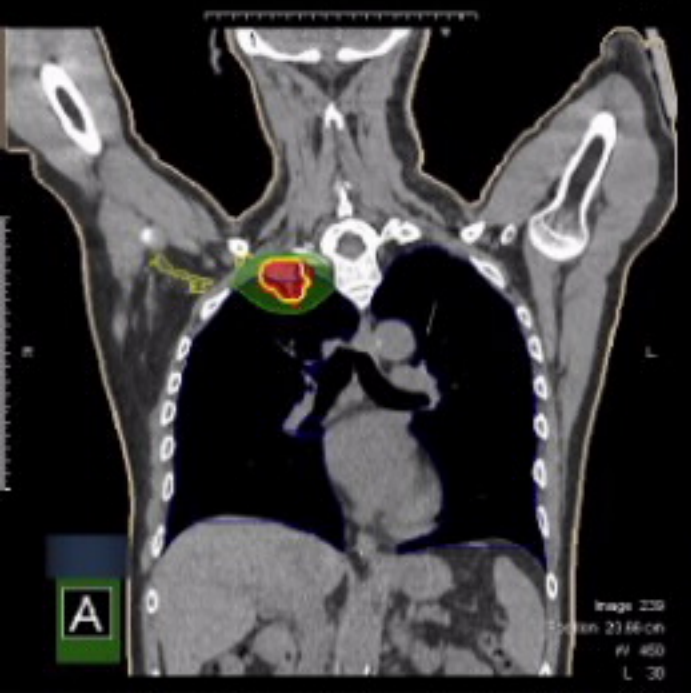
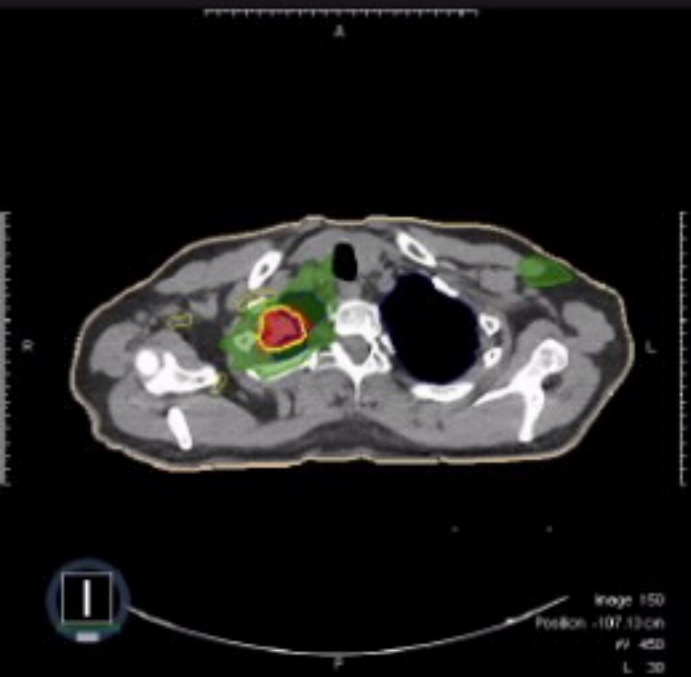
Adapted On-Table



# Adaptive Treatment Planning







5x1000 cGy



5x725 cGy

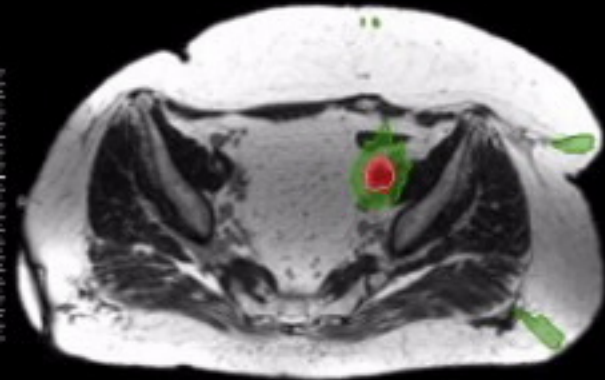


Image 144  
Position -0.13 cm  
W 533  
L 279

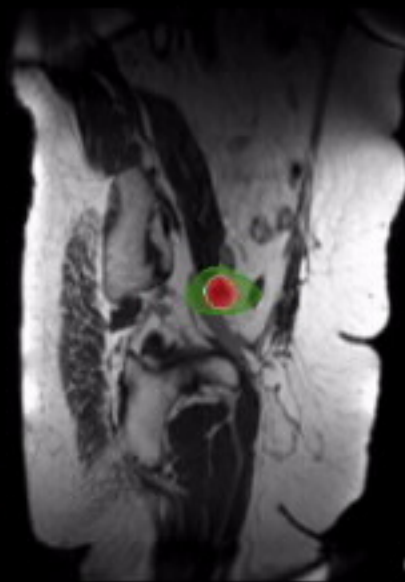
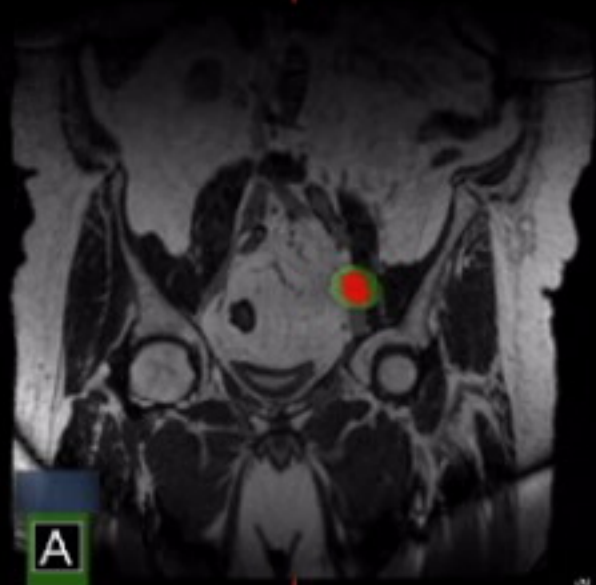


Image 152  
Position 4.56 cm  
W 533  
L 279



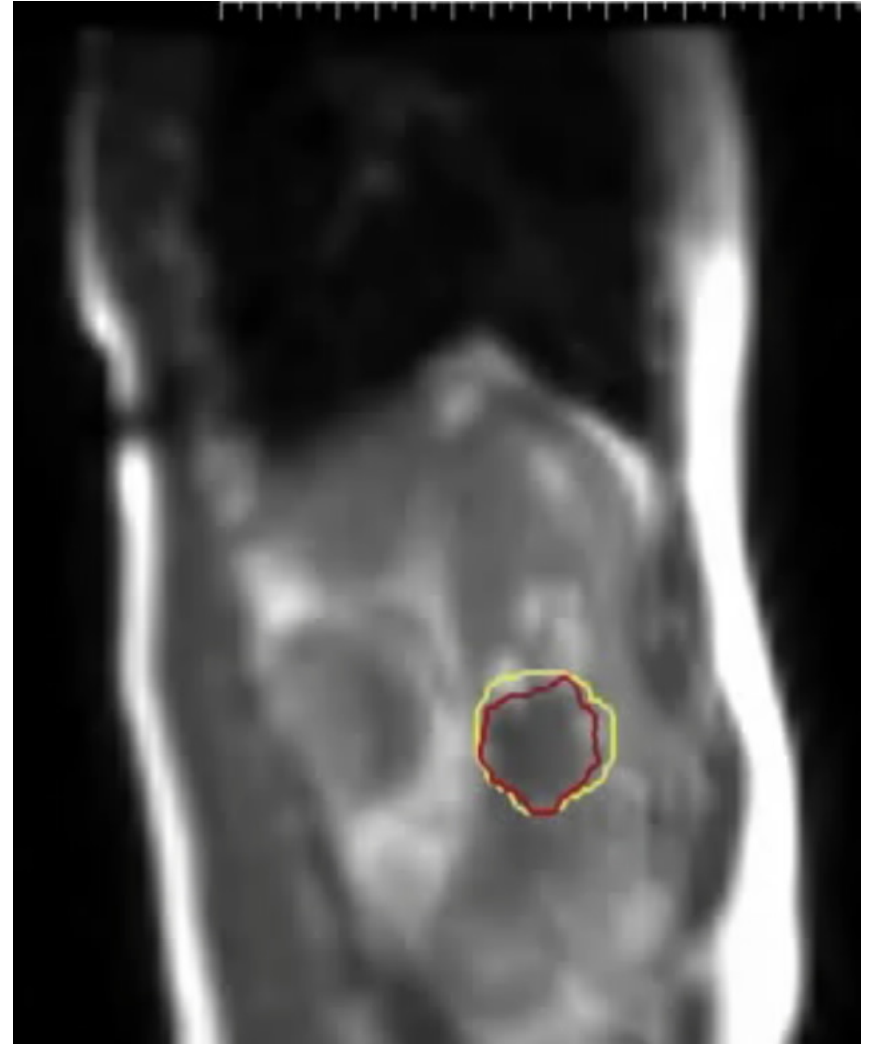
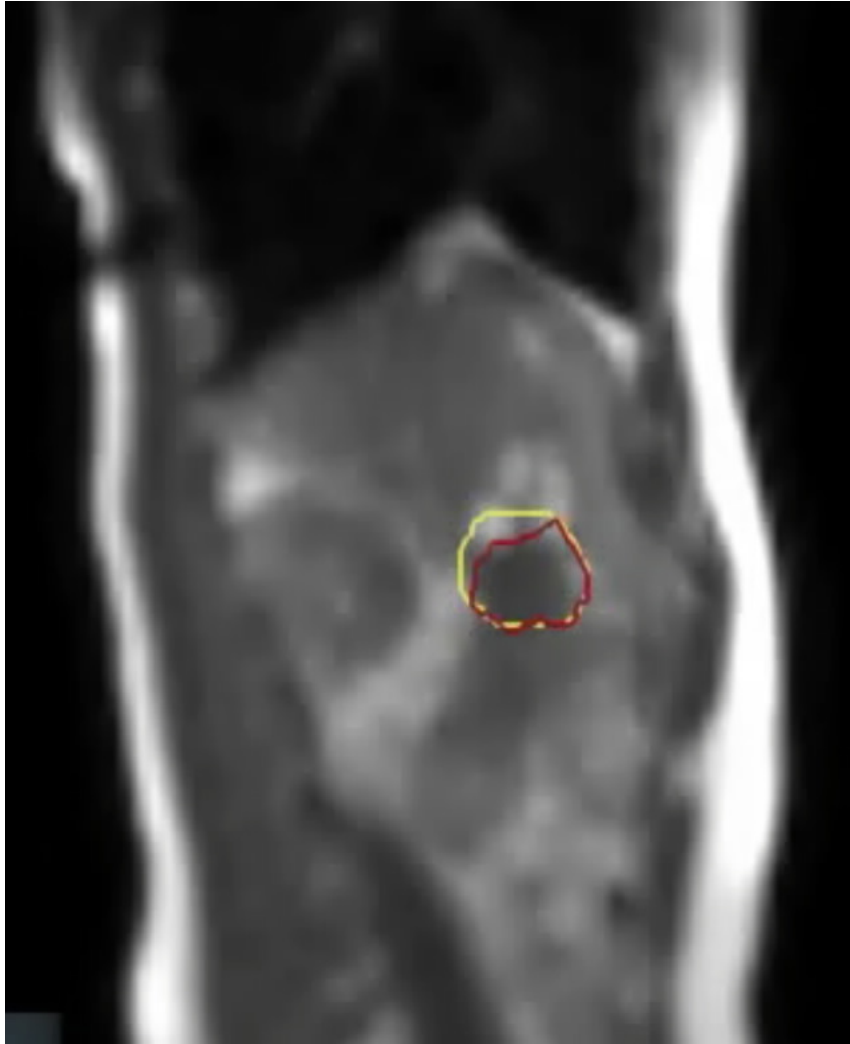
Image 138  
Position 2.07 cm  
W 533  
L 279



W 533  
L 279

Pelvic LN  
Re-RT  
3x1000 cGy

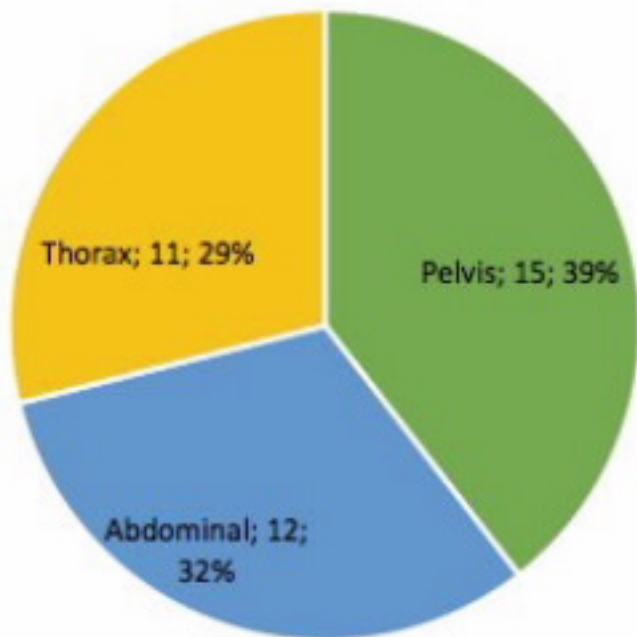
# Deep Inspiration vs End-Exhale



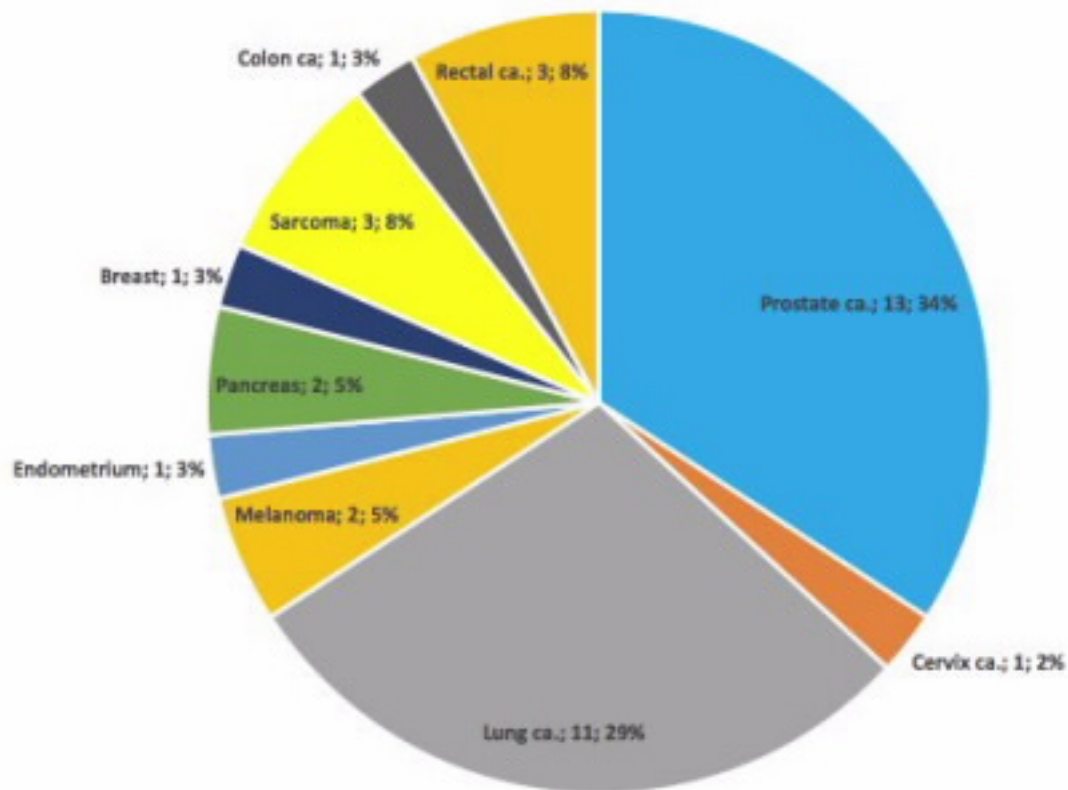
# September – December 2018

Patient Distribution (33 patients/38 fields/ 208 fractions)

Treatment Site

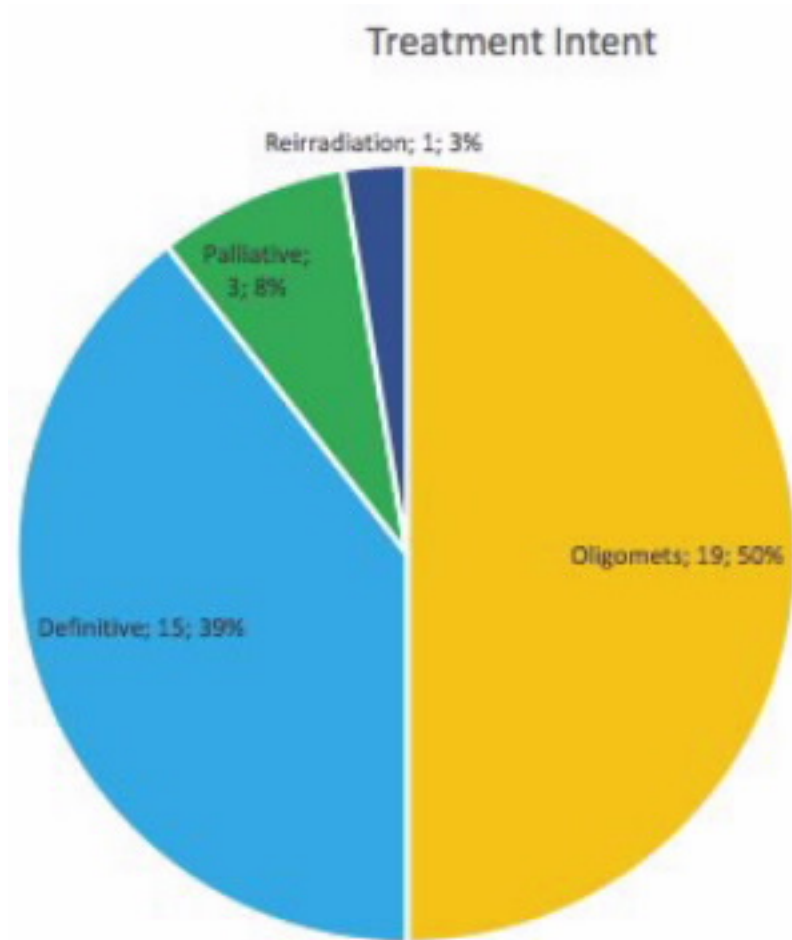


Diagnosis



# September – December 2018

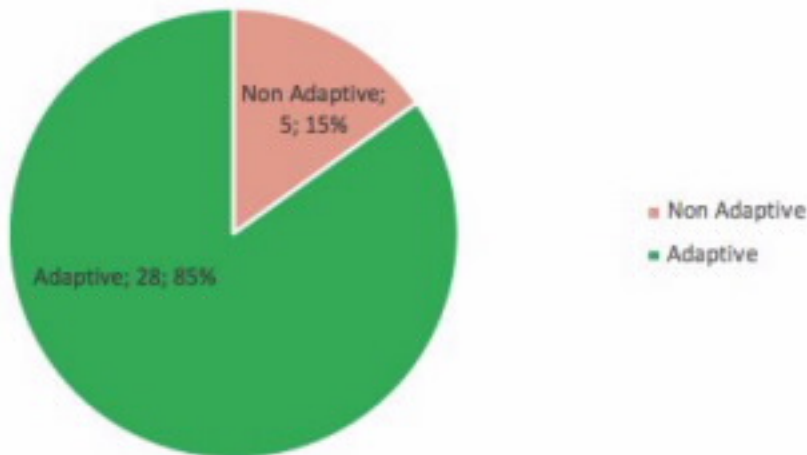
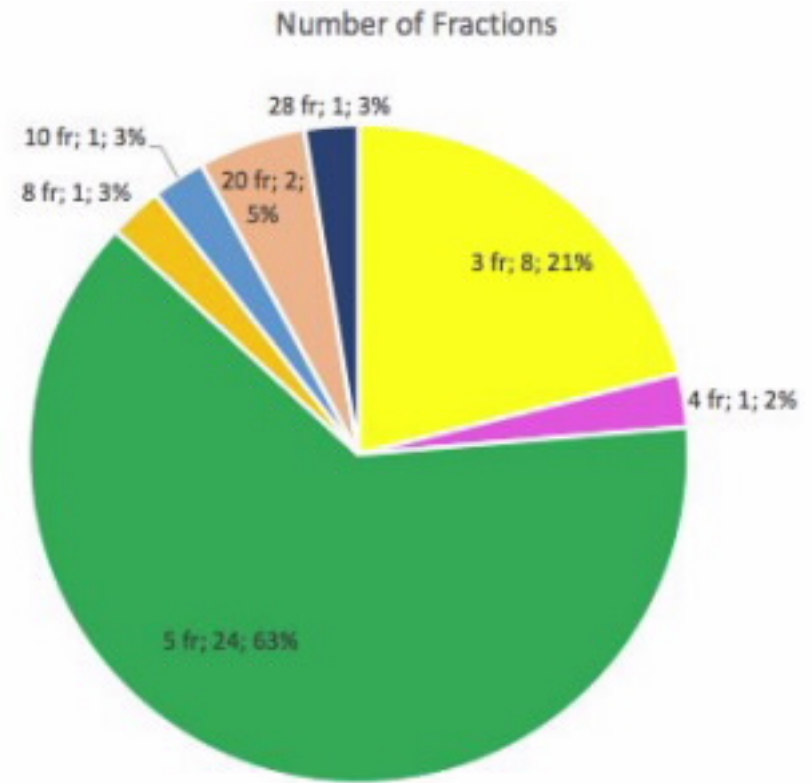
Patient Distribution (33 patients/38 fields/ 208 fractions)



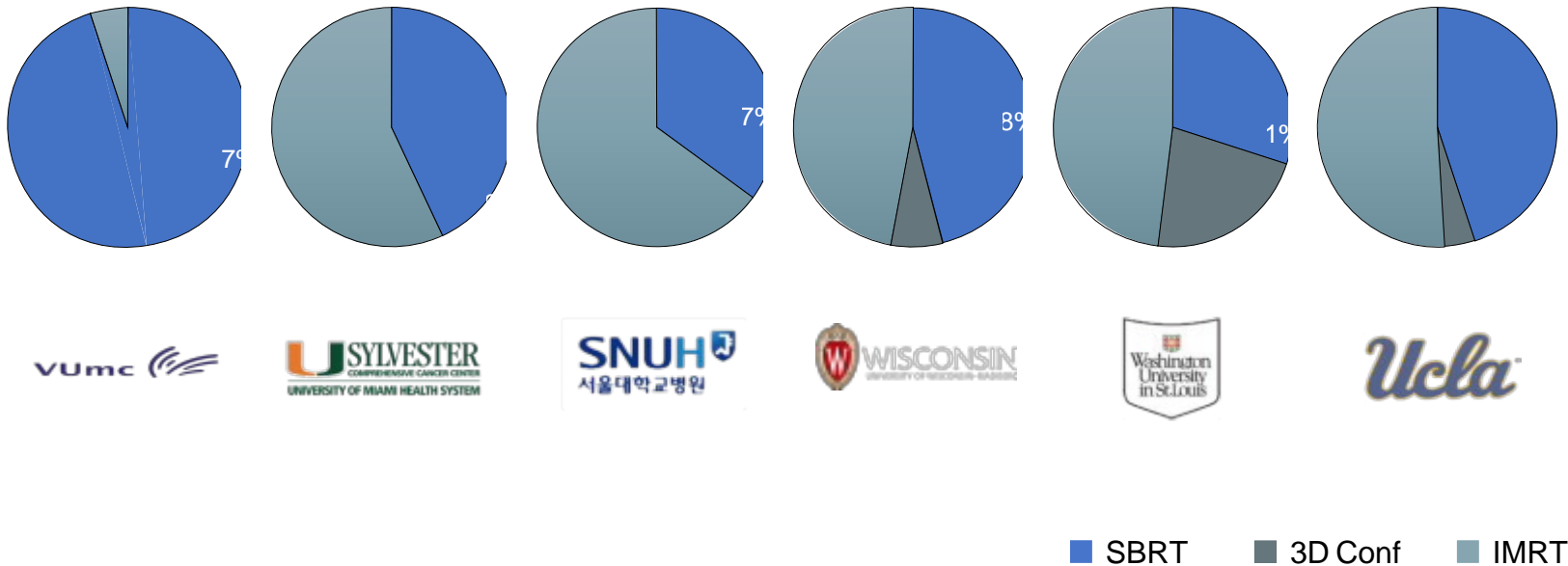
# September – December 2018

Patient Distribution (33 patients/38 fields/ 208 fractions)

	Median	Range
Dose per Fraction (Gy)	7.25 cGy	2.5-18
Total Dose (Gy)	36.25	21-70
Fraction Number	5	3-28

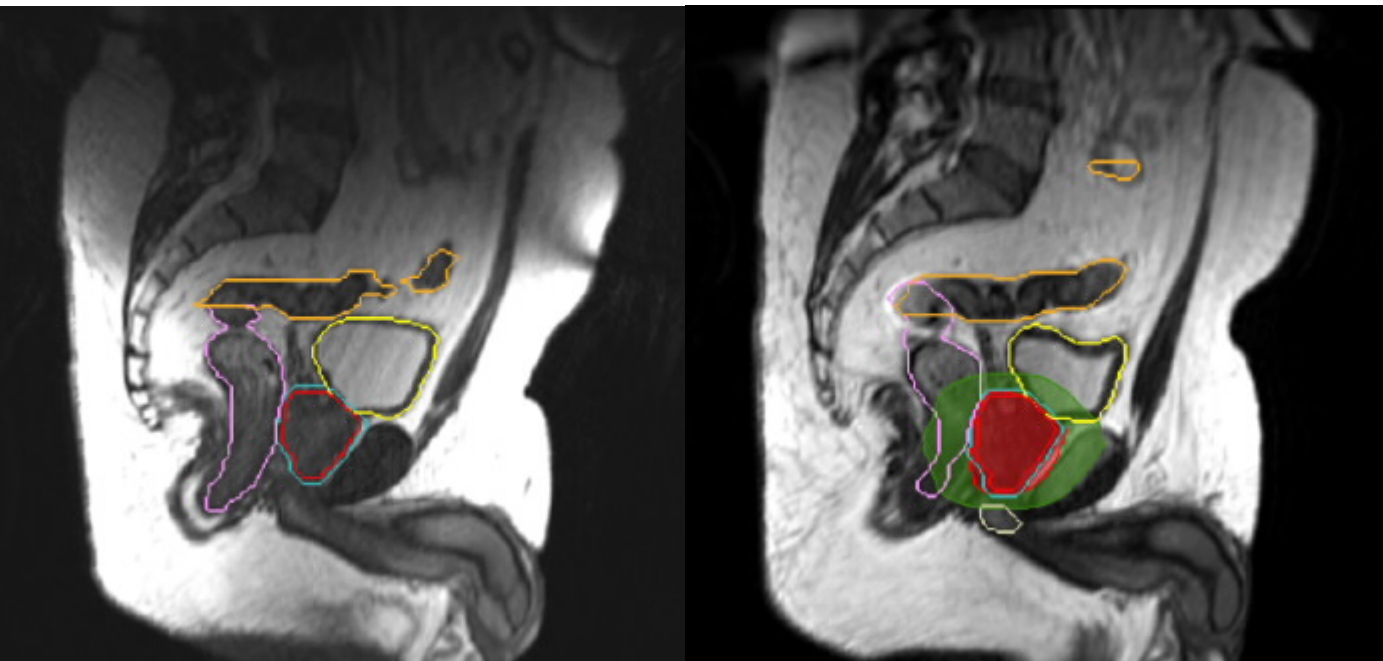


# SBRT vs IMRT vs Conventional Radiotherapy

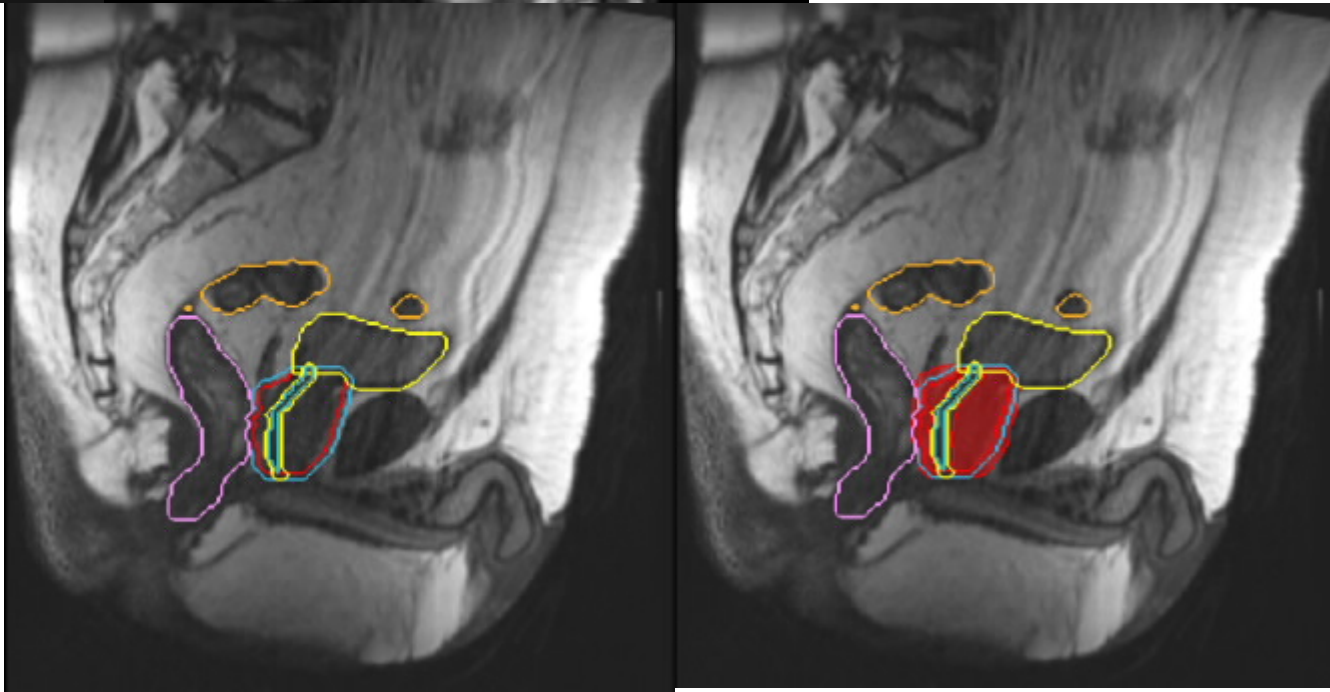




Prostate Cancer  
SBRT 5x725 cGy

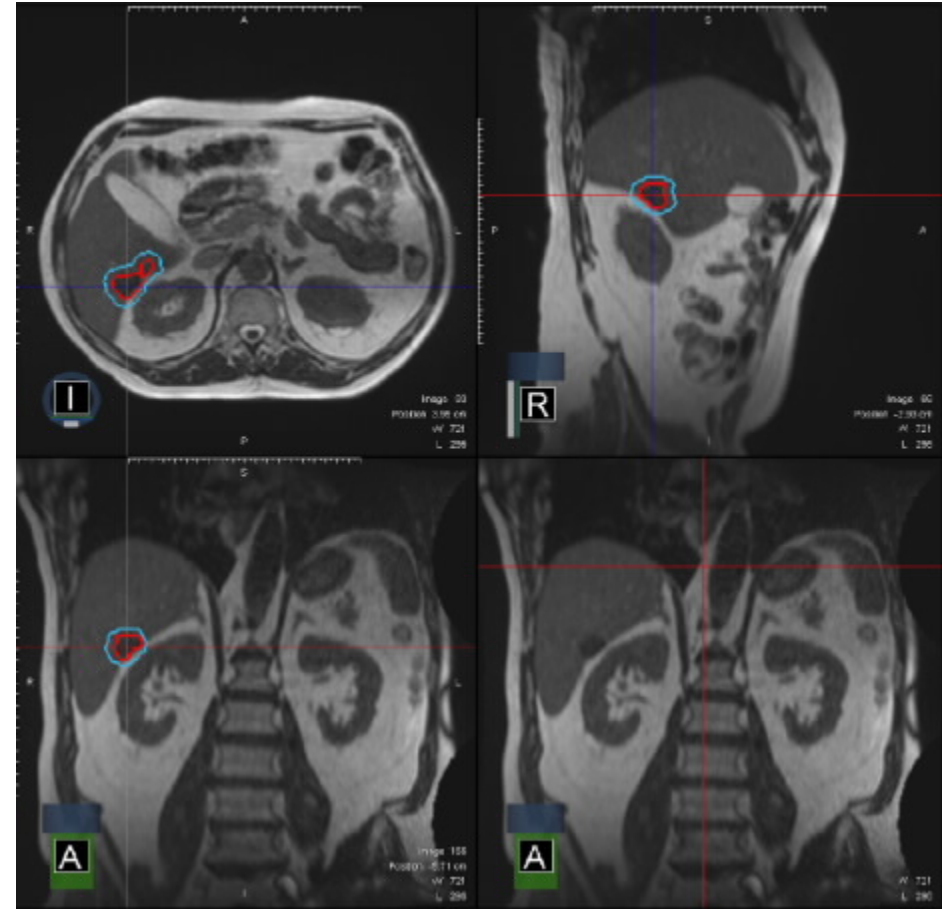
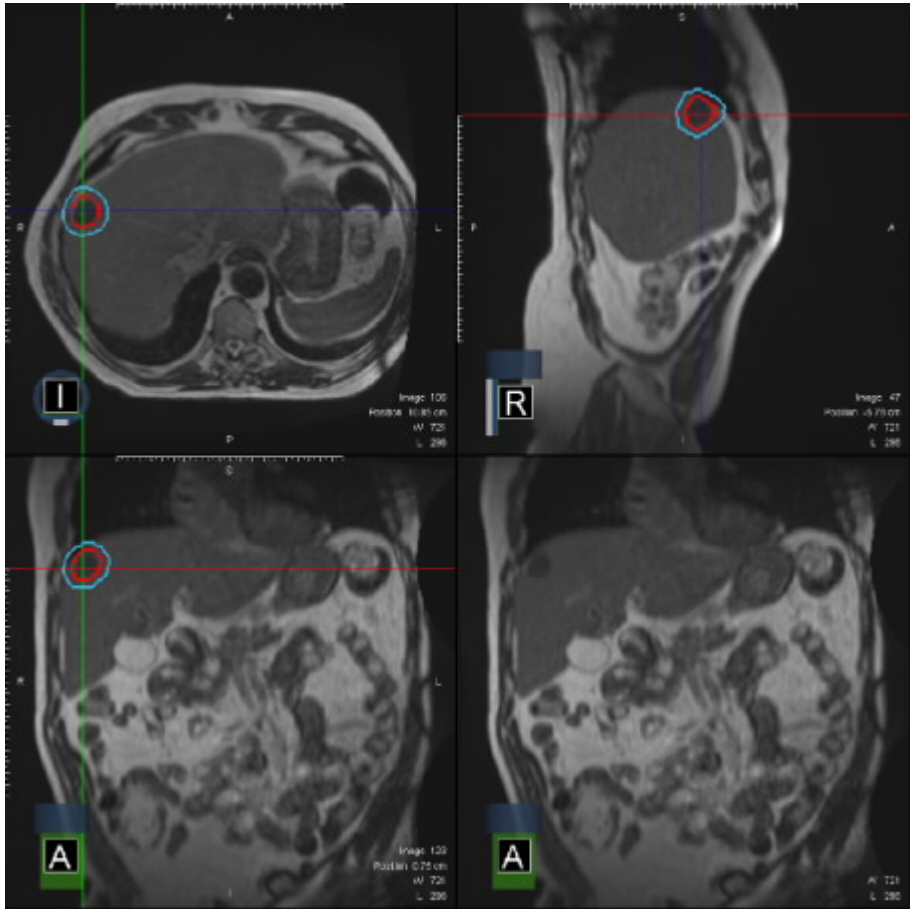


With or without  
Urethral  
Sparing



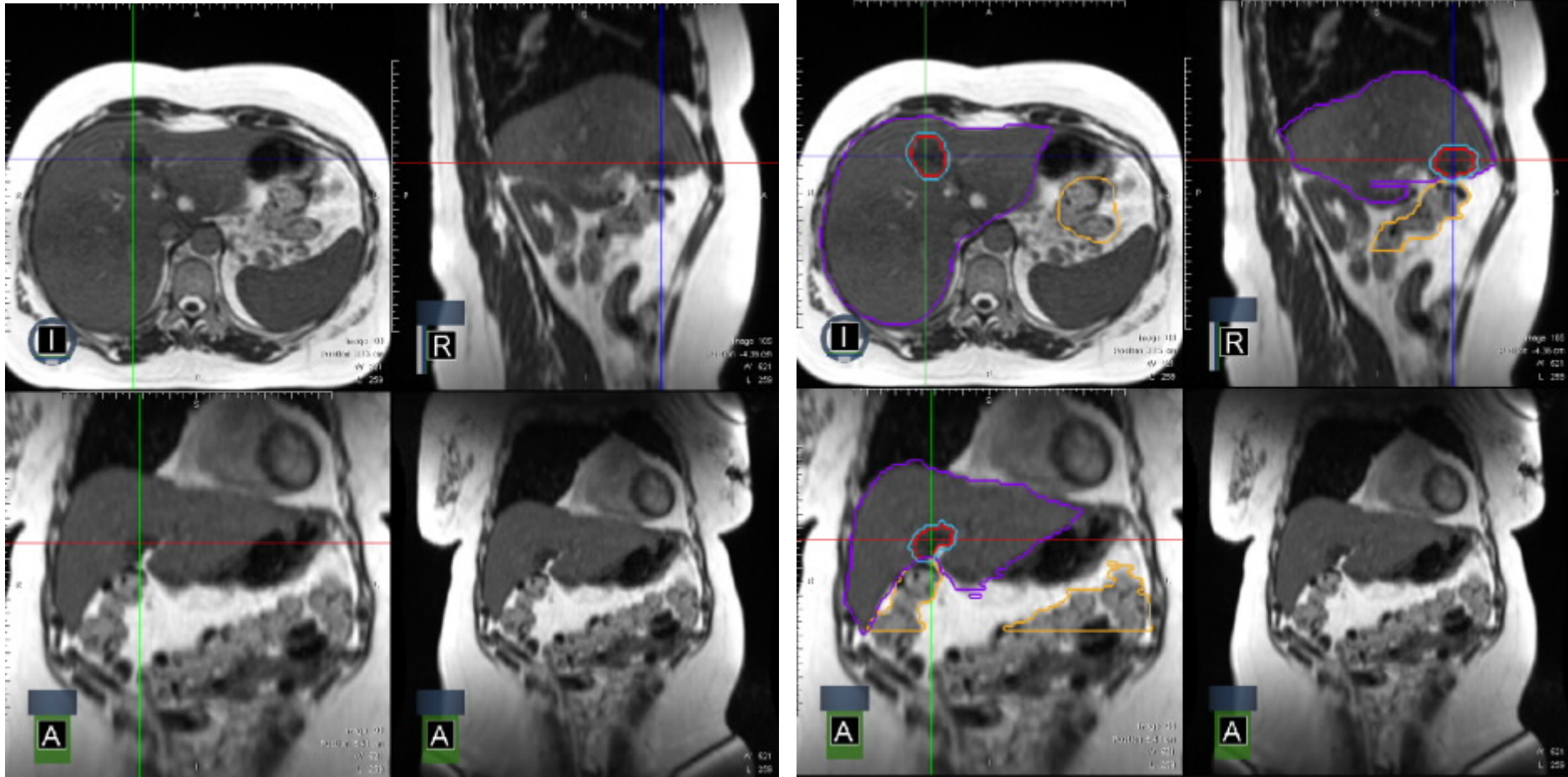
# Liver Metastasis - 2 Lesions

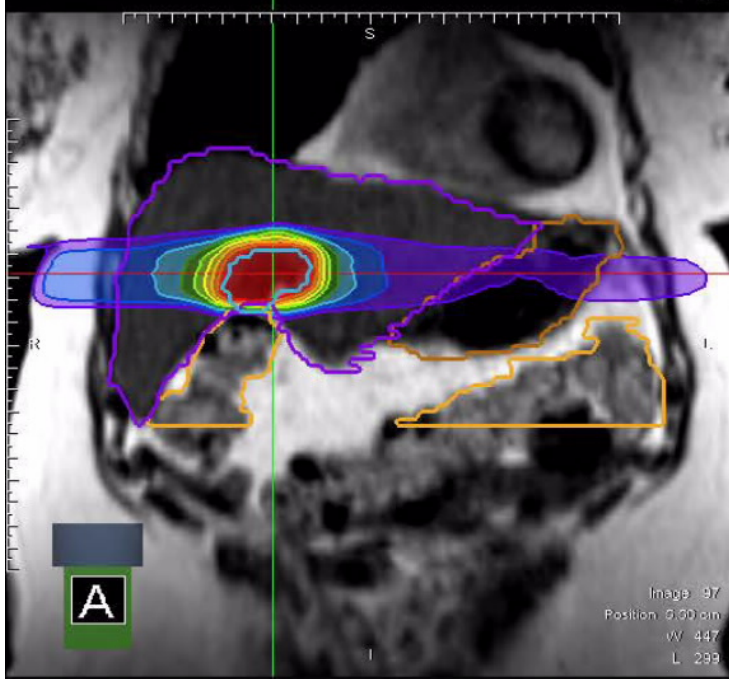
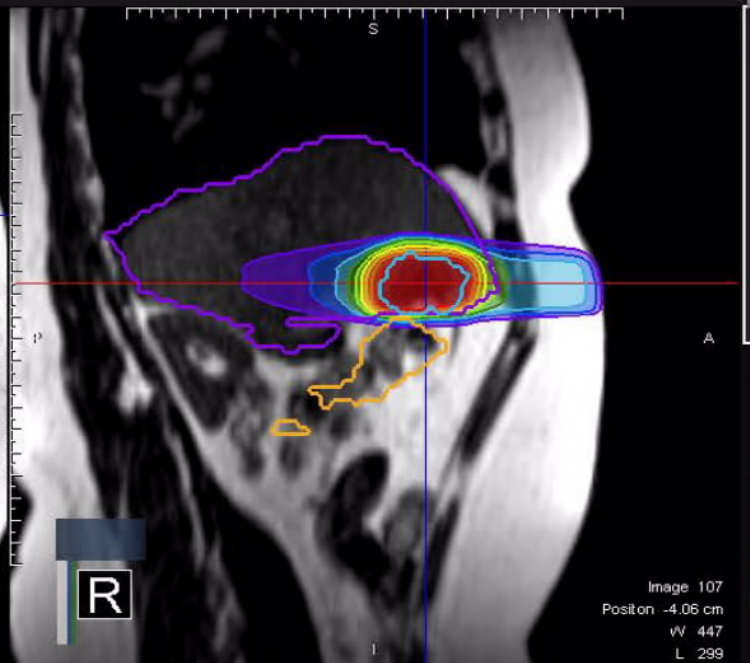
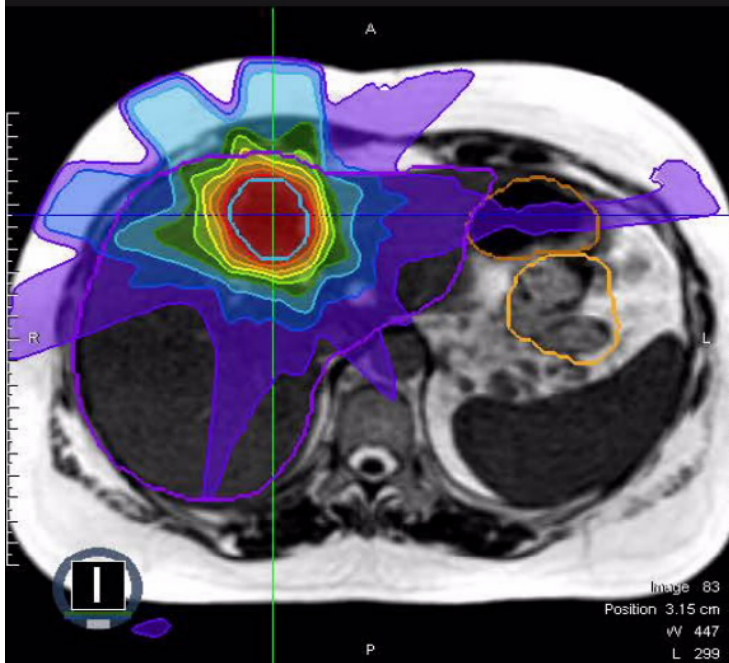
## SBRT 5x1000 cGy



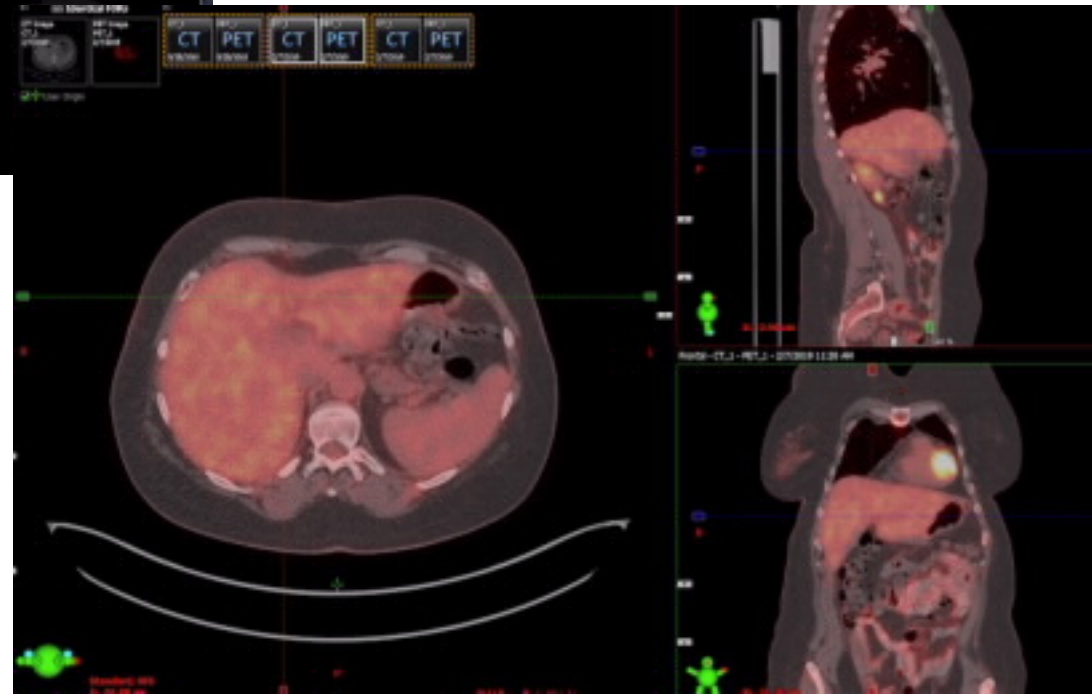
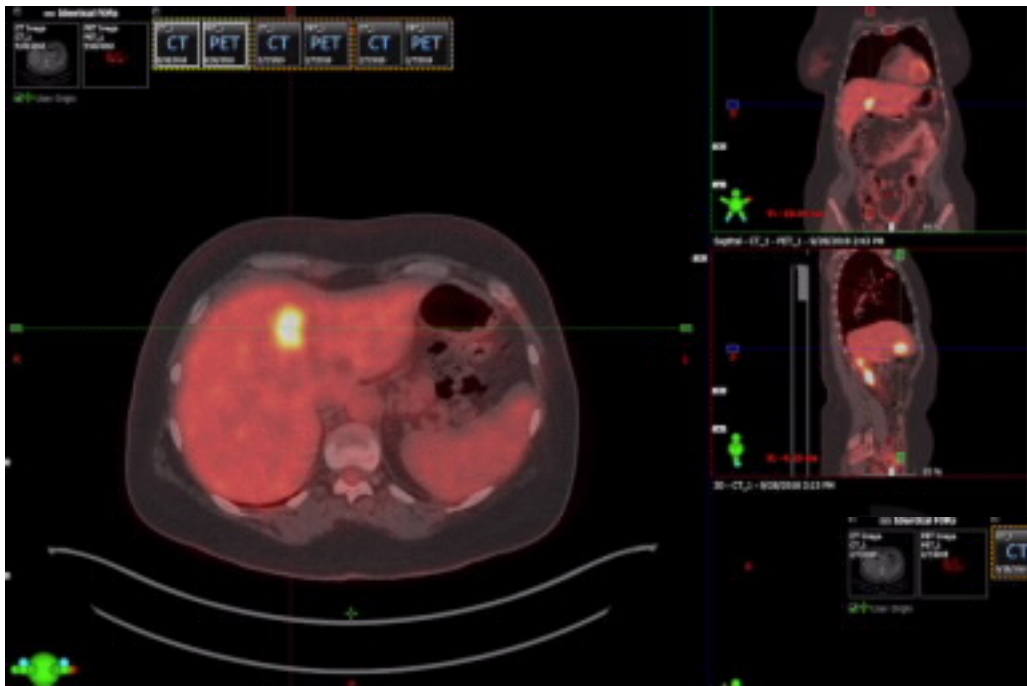
# Liver Metastasis

## SBRT - 8 x 750 cGy

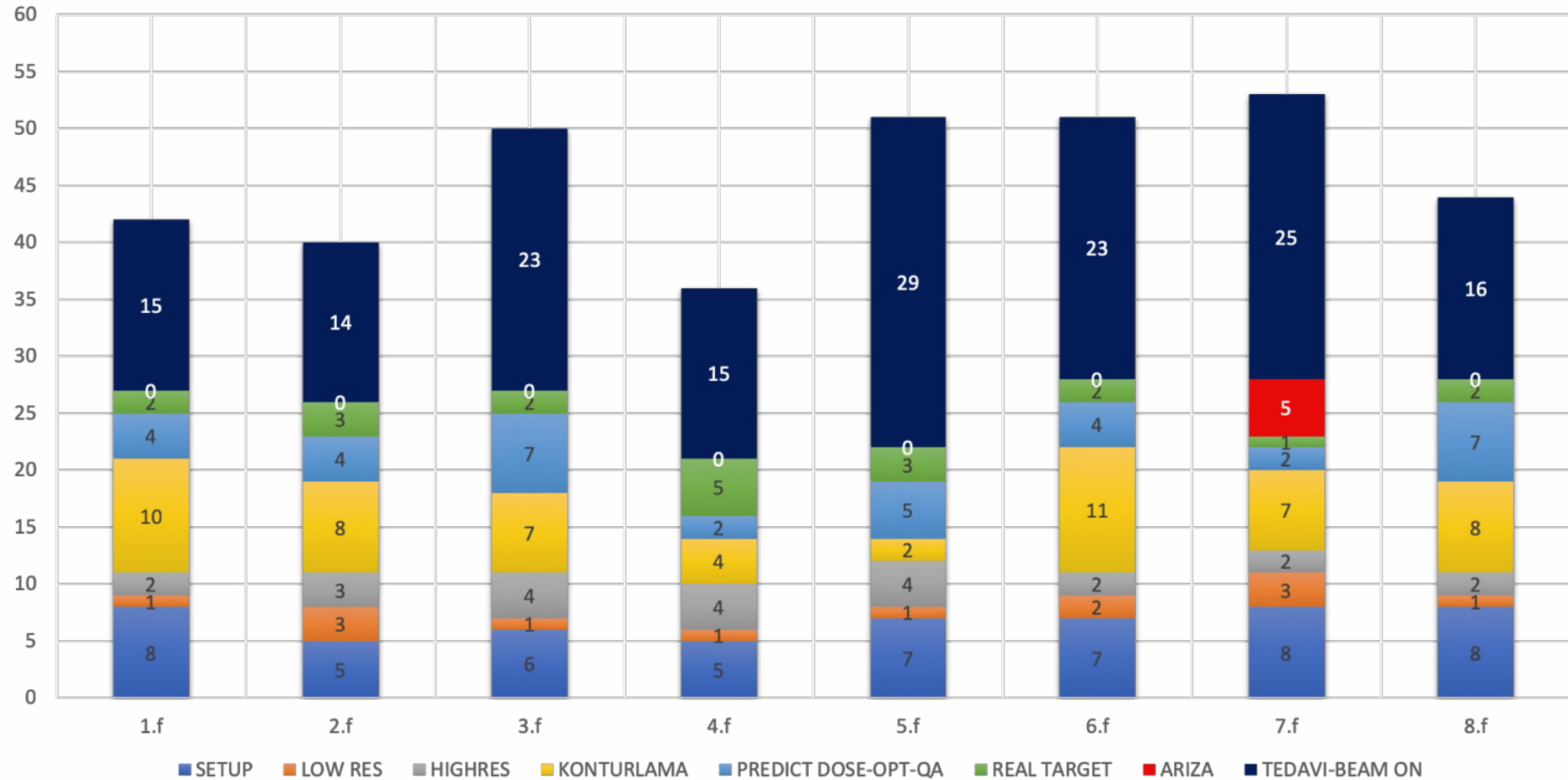




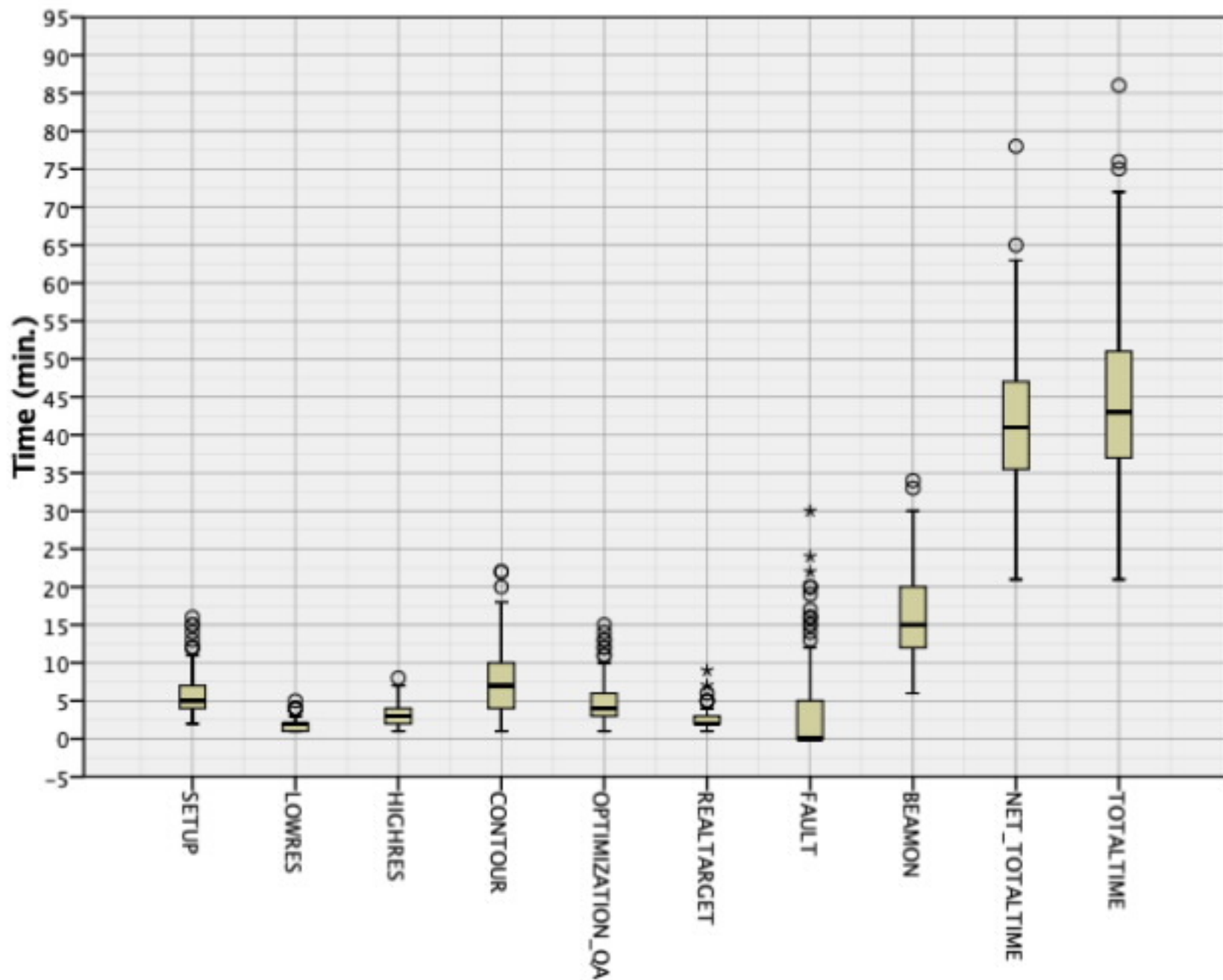
# Post SBRT 3. month - CR



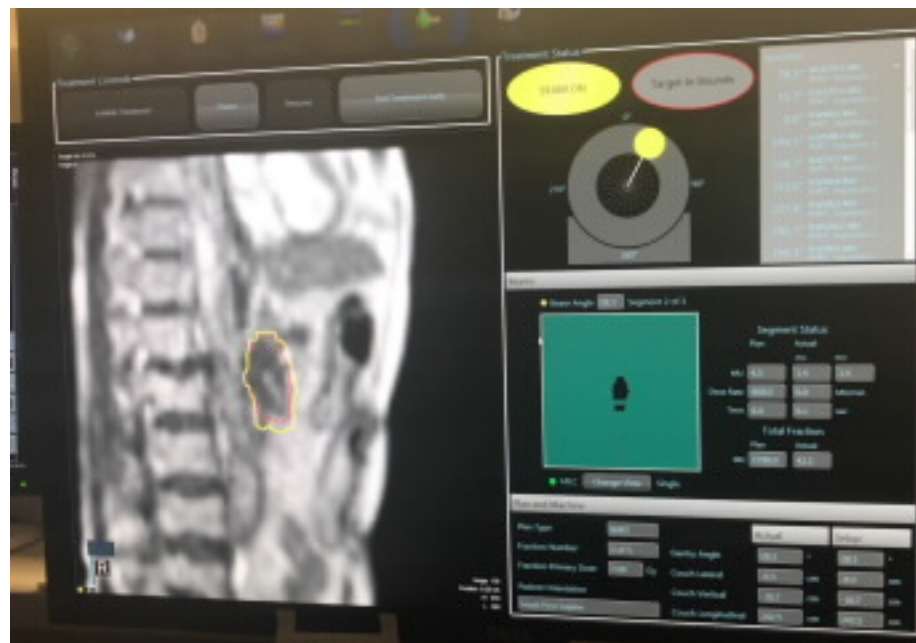
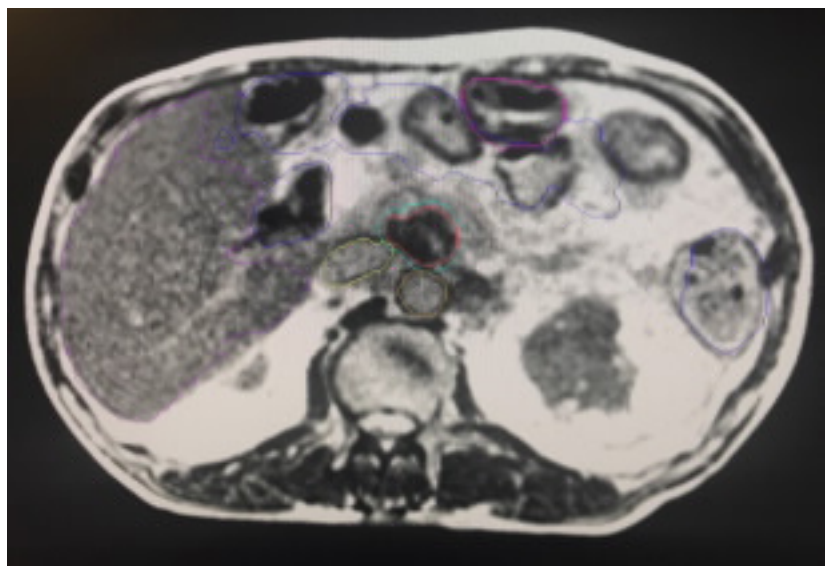
# Overall Tx Time for 8 Fractions



# TIME ANALYSIS OF 208 TREATMENT FRACTIONS



# Pancreatic cancer, local recurrence after Sx+CT+RT





# Ovarian ca, Liver met

Treatment Controls

Enable Treatment

Targeted 27.5%  
Targeted

image 470  
dim: 528 cm  
W: 507  
L: 414

Treatment Status

BEAM OFF Target Out of Bounds

0° 90° 180° 270°

0.00.0	0.00.0	Segment 1
1.00.2	1.00.2	Segment 1
1.01.0	1.01.0	Segment 1
2.21.5	2.21.5	Segment 2
2.40.2	2.40.2	Segment 2
2.10.9	2.10.9	Segment 2
3.00.0	3.00.0	Segment 3
3.32.3	3.32.3	Segment 3
0.0.0	0.0.0	Segment 4
2.7.7	2.7.7	Segment 4

Beams:

Beam Angle 332.3 Segment 2 of 5

Segment Status

	Plan	Actual	HL	HL
MU	67.4	8.3	8.3	
Dose Rate	800.0	0.0	MU/min	
Time	32.7	0.8	sec	
Total Fraction				
	Plan	Actual		
MU	698.5	328.4		

MLC  Single

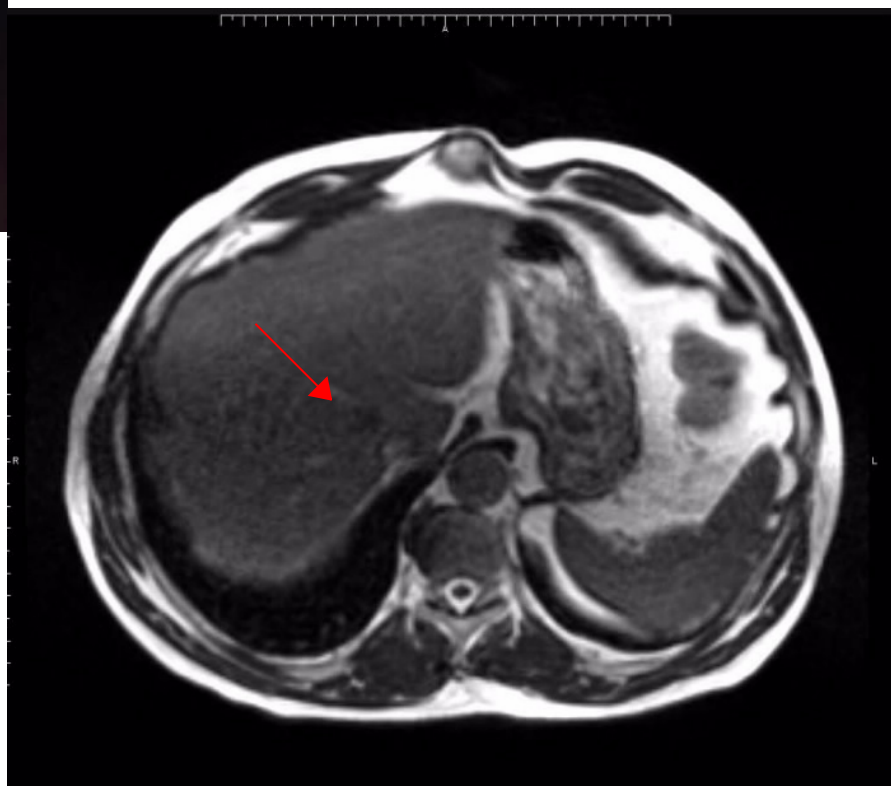
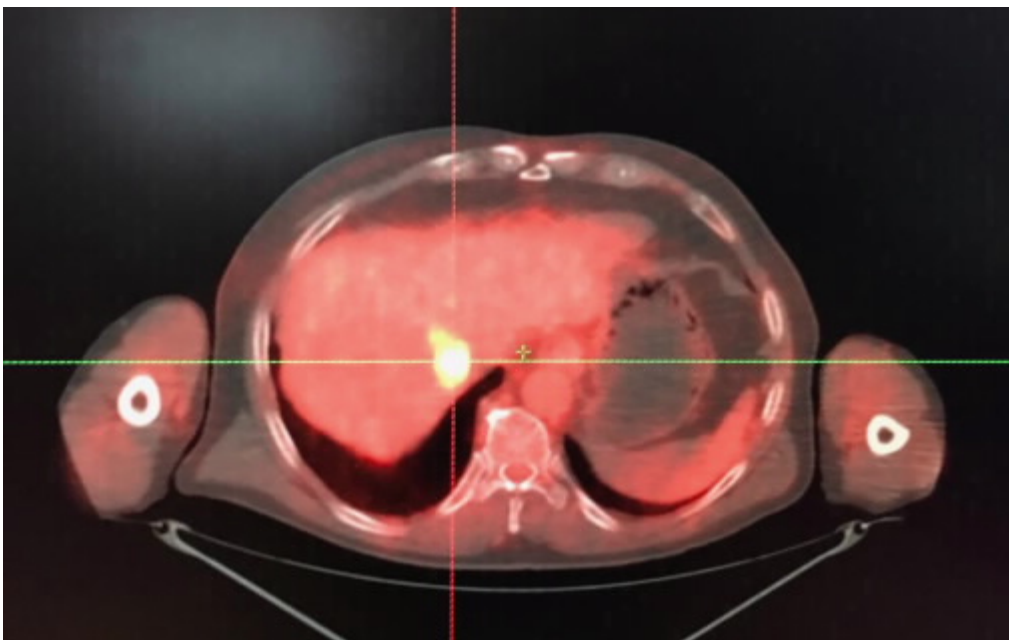
Plan and Machine

Plan Type	Actual	Setup
Fraction Number	2 of 5	
Fraction Primary Dose	33.00 Gy	
Gantry Angle	332.3	332.3
Couch Lateral	-6.7	-6.7
Couch Vertical	-15.0	-15.8
Couch Longitudinal	223.4	227.6

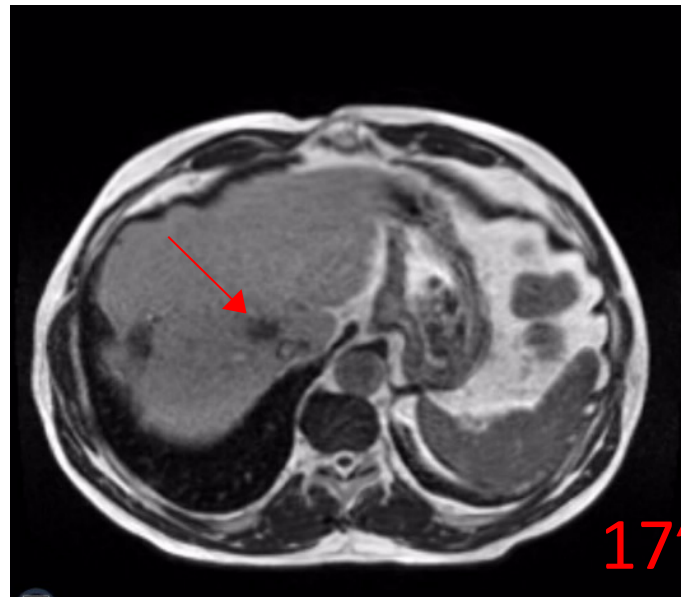
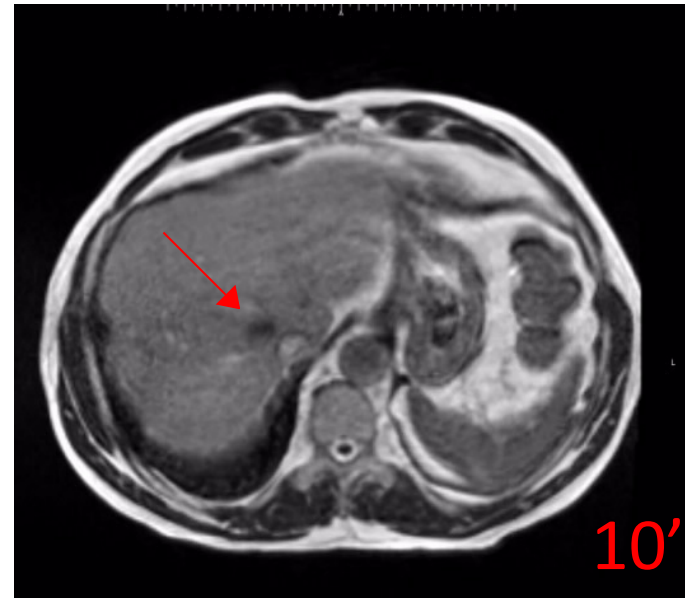
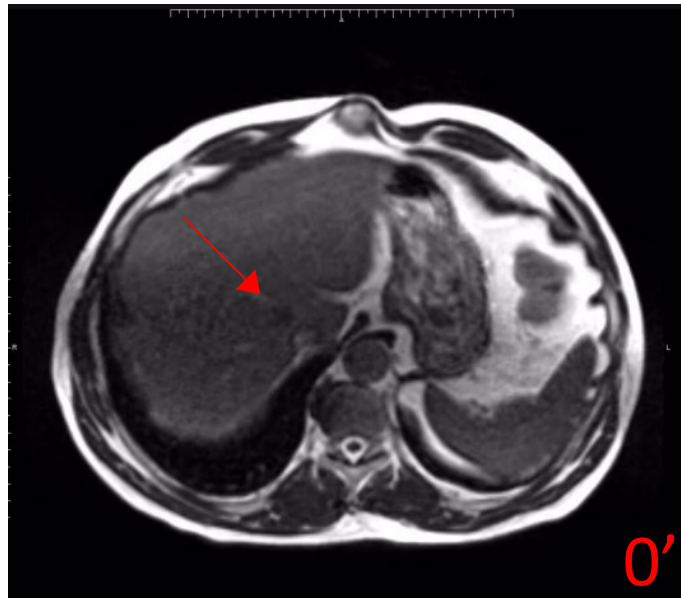
Plan Type

Head First Supine

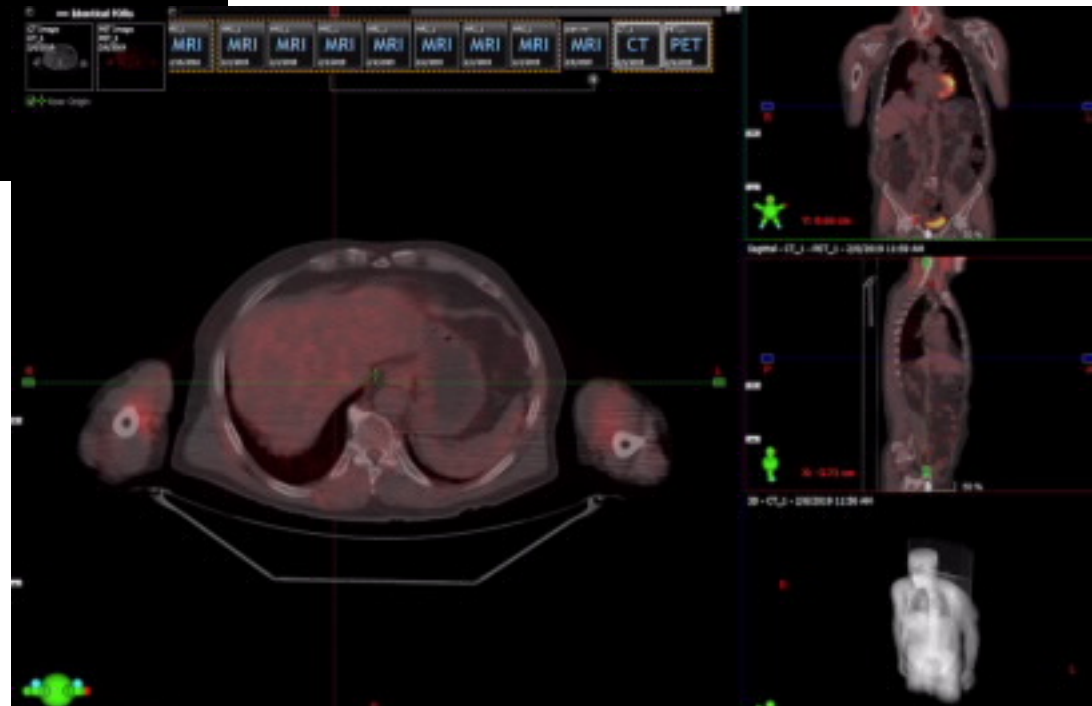
# Invisible Liver Metastasis



# 0-27 Minutes After Gadoxetate (Primovist)

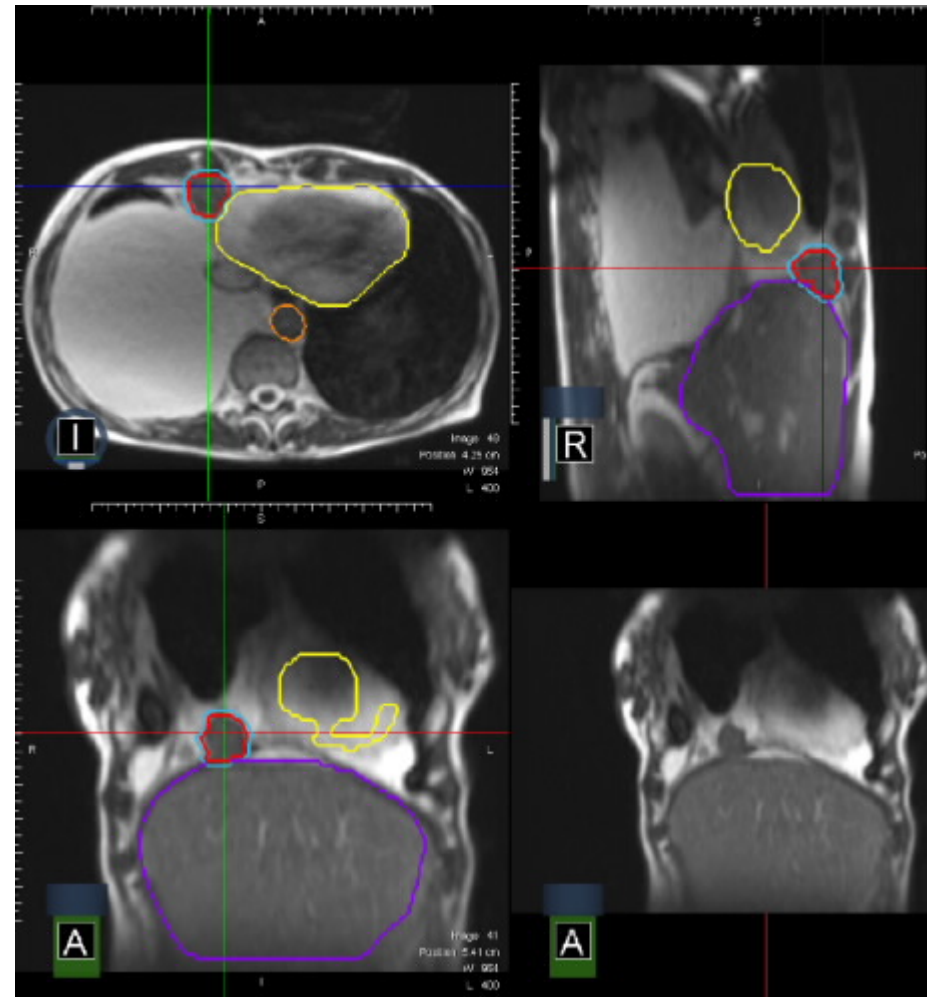
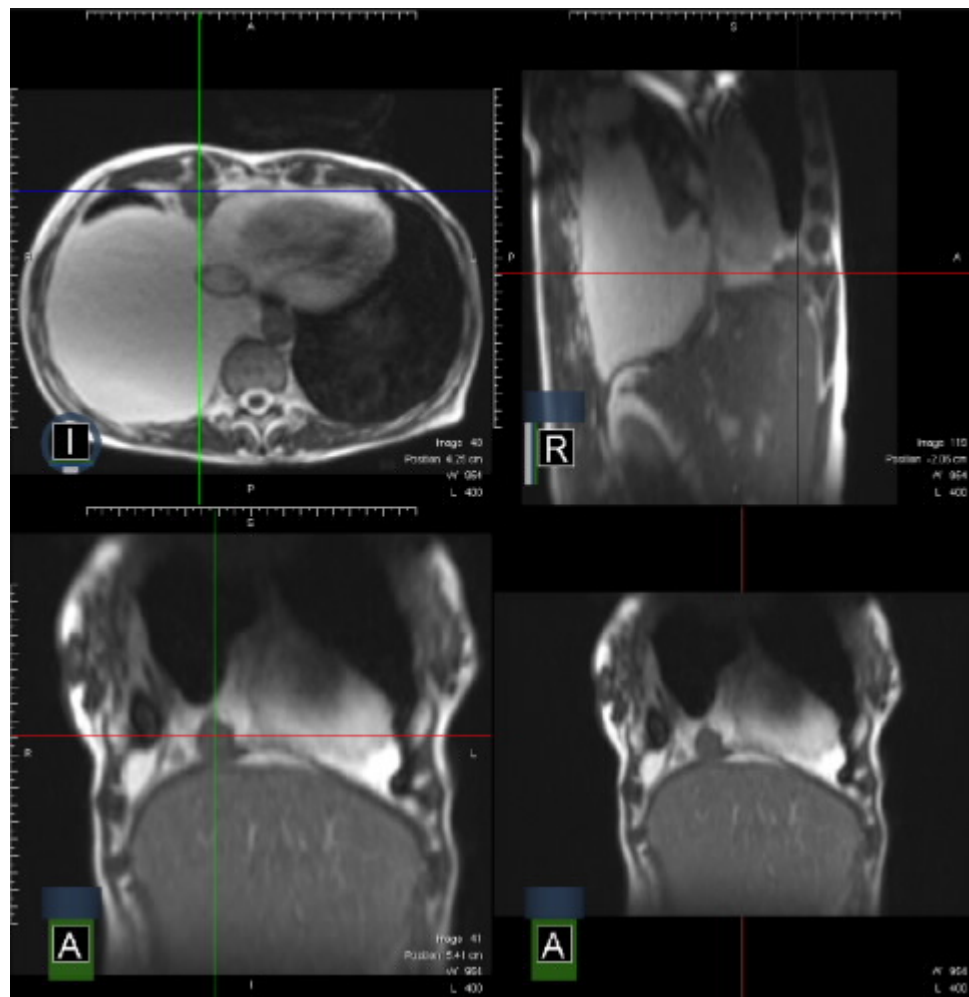


# Post SBRT 3 months - CR

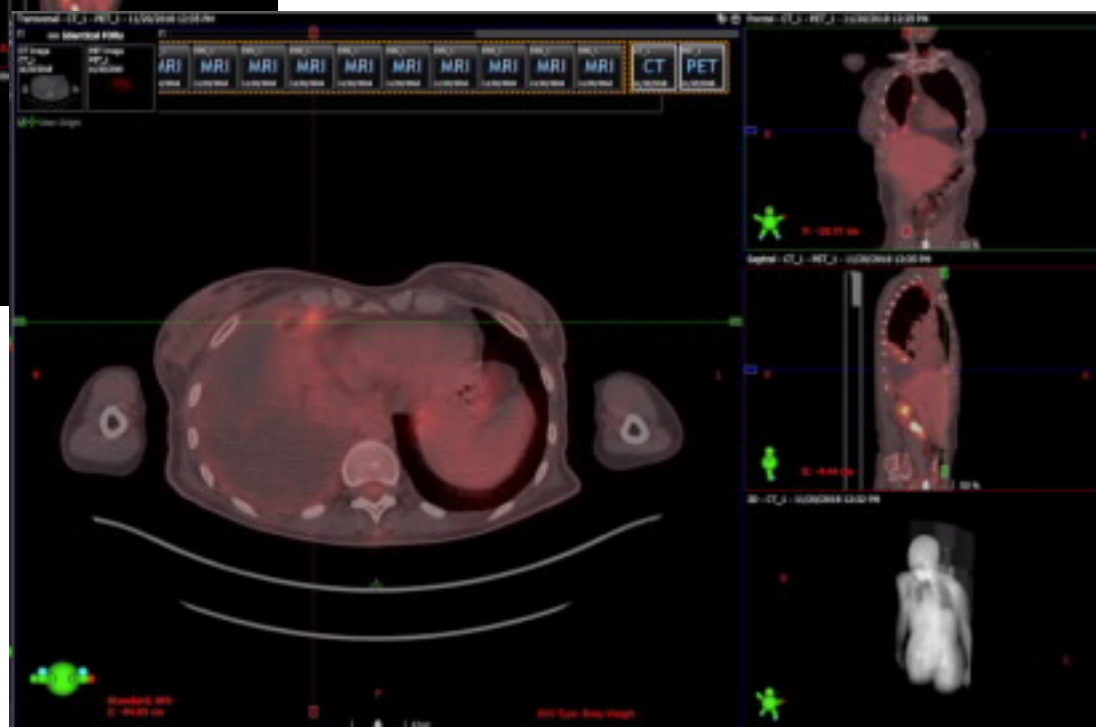
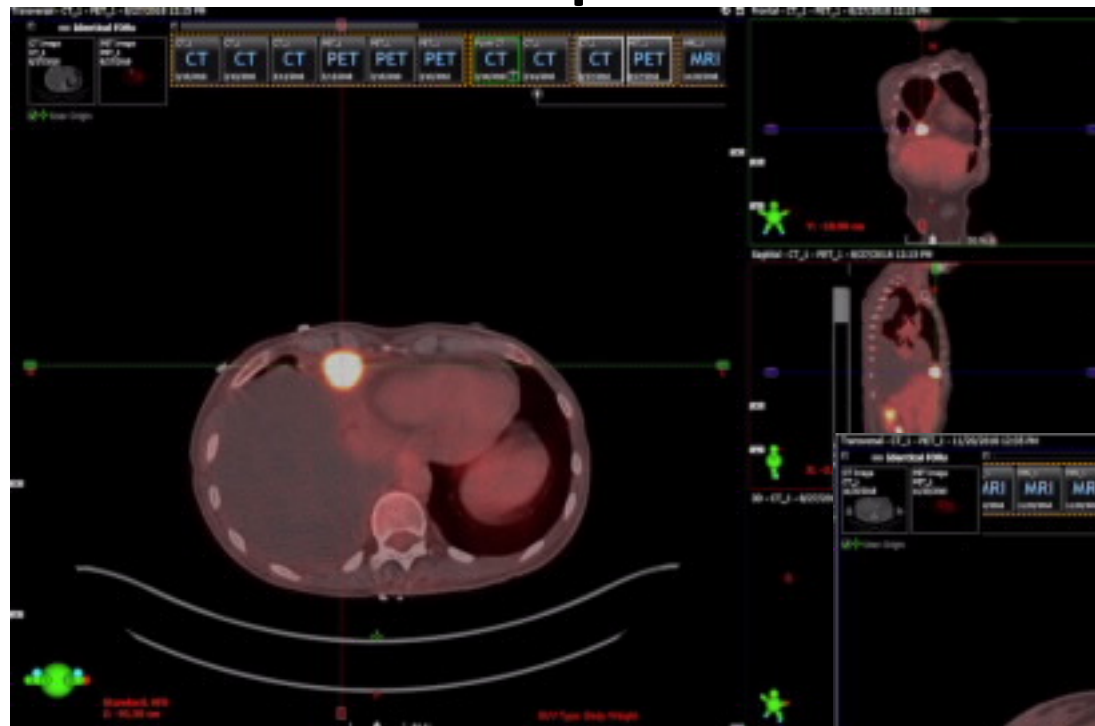


# Oligometastatic Lung adenoca

## SBRT



# Oligometastatic Lung Adeno ca Response 3 Months Later



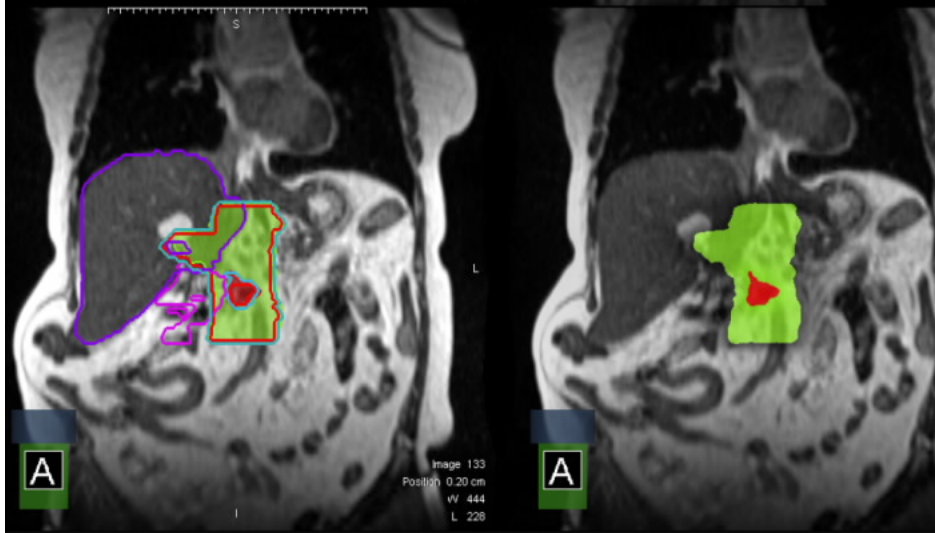
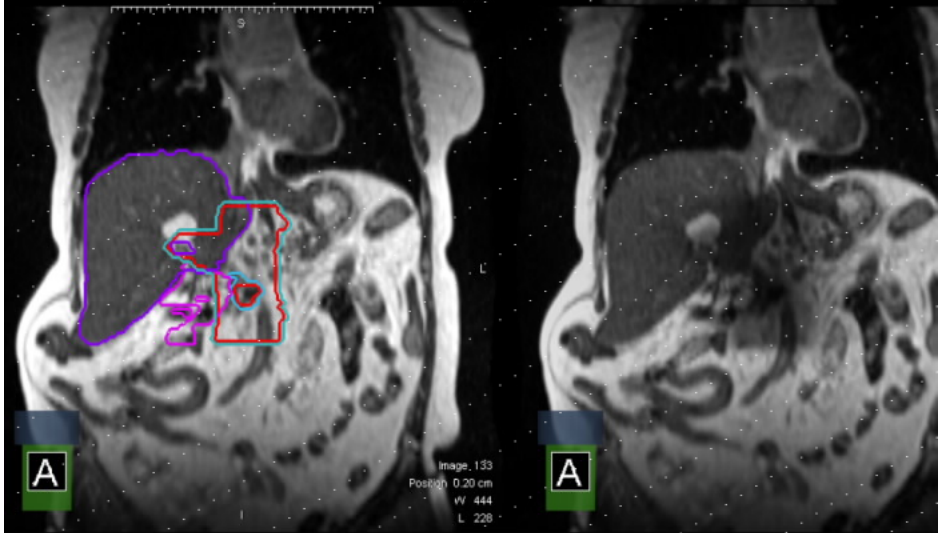
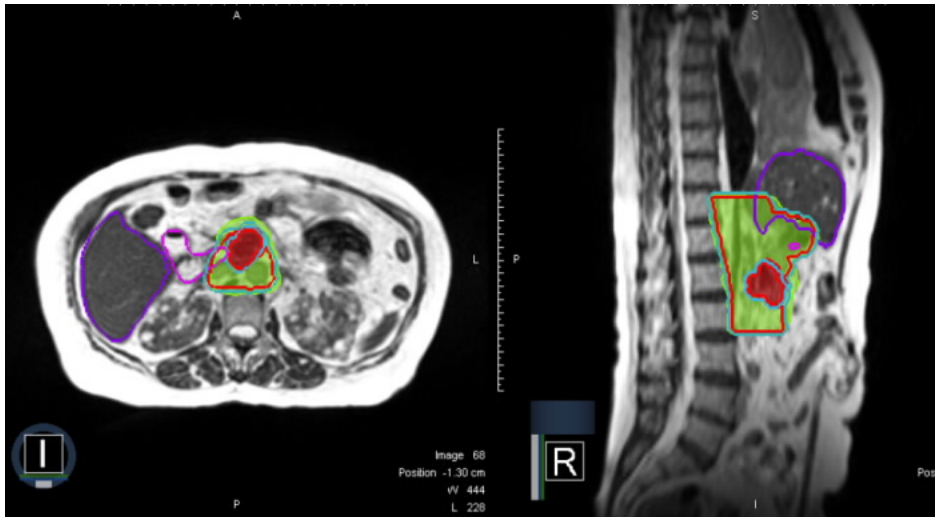
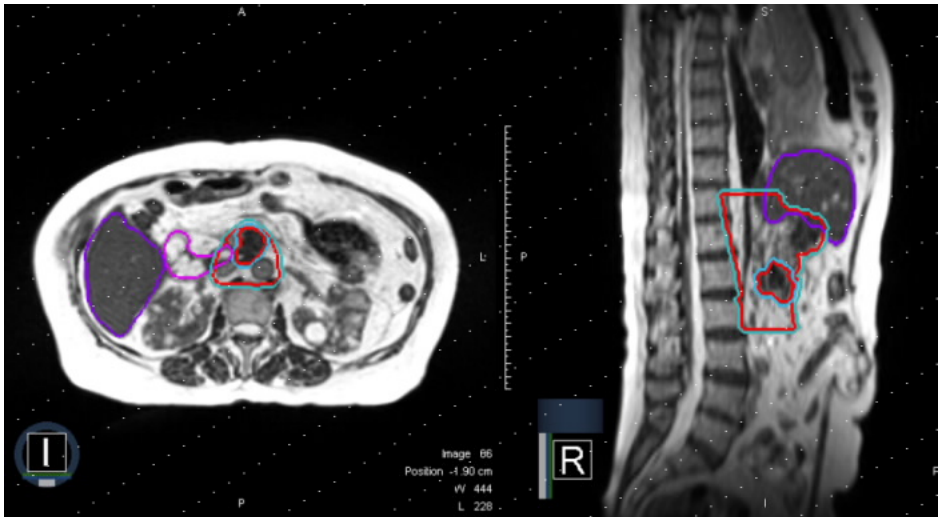
# Pancreatic Cancer – SBRT 5 x 800 cGy

The screenshot displays a medical planning system interface for Stereotactic Body Radiation Therapy (SBRT) treatment of pancreatic cancer. The interface is divided into several sections:

- Top Left:** Axial CT scan slice (Image 58) showing the target (red) and organs at risk (OARs) contours (green, blue, purple).
- Top Right:** Axial CT scan slice (Image 142) showing the target and OARs contours.
- Bottom Left:** Axial CT scan slice (Image 129) showing the target and OARs contours.
- Bottom Right:** Axial CT scan slice (Image 140) showing the target and OARs contours.
- Control Panel (Right Side):**
  - Draw Contours / Auto-Contouring / Iso-Intensity Contouring / Rules:** Buttons for Margin Expansion, Boolean, Auto-Contour All, Save Template, Auto-Contour Skin, Threshold (97), and Margin (3).
  - Un-Approve Contours / Clean Up:** Buttons for un-approving contours and cleaning up the plan.
  - Structures:** A list of anatomical structures with checkboxes for 'Add', 'Remove', and 'Rename'. The list includes: GTV 1, GTV 2, AORTA, Celiac arter, DUODENUM, Esophagus, Kidney L, Kidney R, Large Bowel, LIVER, PANCREAS, Sm Arter, Spinal cord, STOMACH, and Small Bowel. Each structure has a 'Deform' checkbox.
  - Display:** A section for displaying the plan, including:
    - Points of Interest:** A list of points of interest, currently showing '2.0 Isocenter' with 'View All' and 'View None' buttons.
    - Beams:** A section for displaying the beams.
    - Dose View:** A section for displaying the dose distribution, including a 'Colorwash' option and a 'Dose Opacity' slider set to 0.5.
    - Iso-dose Lines:** A list of isodose lines with their corresponding dose and percentage values, including buttons for 'Add', 'Clear', 'Auto', 'Save', 'Load', 'View All', and 'View None'. The list includes: 44.00 Gy (110.0%), 40.00 Gy (100.0%), 36.00 Gy (90.0%), 32.00 Gy (80.0%), 28.00 Gy (70.0%), 24.00 Gy (60.0%), 20.00 Gy (50.0%), and 16.00 Gy (40.0%).

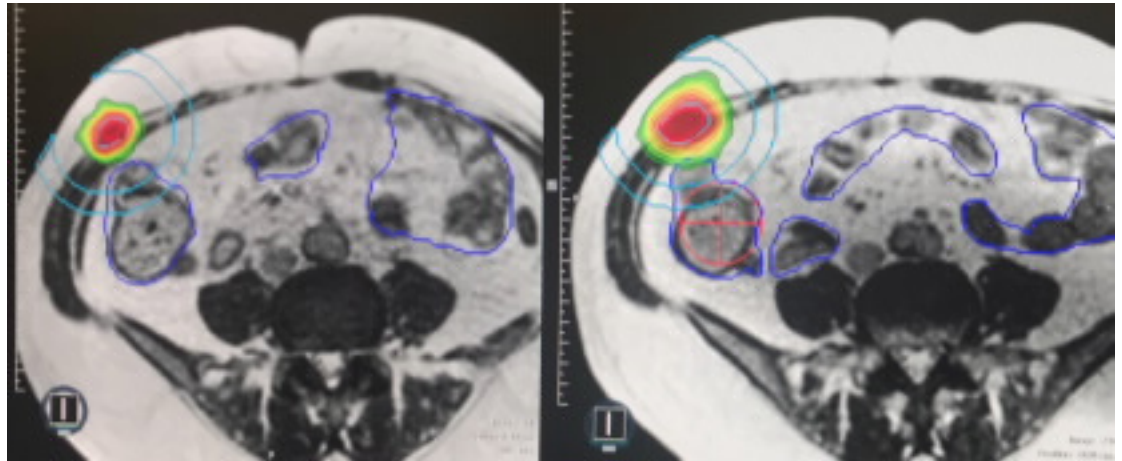
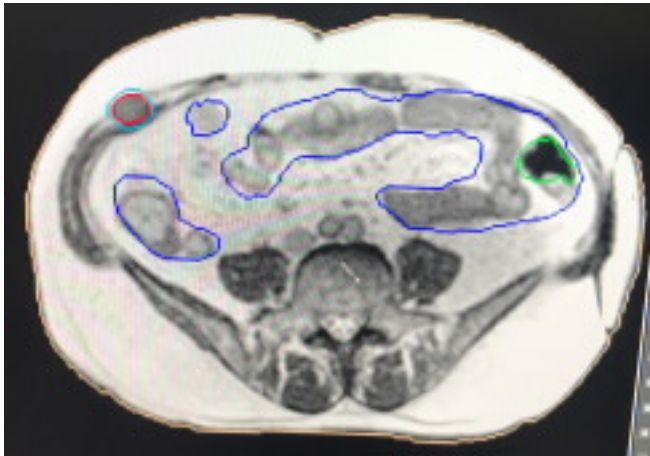
# Ampullary Cancer, Postop Recurrent

SIB: 4/3 Gy x 15 Fr: 60/45 Gy + Capec.





# SCLC, rectus muscle met



Treatment Controls

Enable Treatment

Pause

Resume

End Treatment Early

Target Dose: 18.0 Gy  
Target Dose:



Stage 237  
Position: -1.49 cm  
in 676  
4.436

Treatment Status

BEAM OFF

Target Out of Bounds



Beam Angle	Dose Rate	MU	Segment
55.4°	0.01288.1 MU	0.01288.1 MU	Segment 2
138.5°	0.01288.1 MU	0.01288.1 MU	Segment 1
160.2°	0.01288.1 MU	0.01288.1 MU	Segment 1
193.8°	0.01288.1 MU	0.01288.1 MU	Segment 1
221.5°	0.01288.1 MU	0.01288.1 MU	Segment 1
249.2°	0.01288.1 MU	0.01288.1 MU	Segment 1
276.9°	0.01288.1 MU	0.01288.1 MU	Segment 1
304.6°	0.01288.1 MU	0.01288.1 MU	Segment 1
332.3°	0.01288.1 MU	0.01288.1 MU	Segment 1

Beams

Beam Angle: 138.5 Segment 2 of 2



Segment Status

Plan	Actual	MU
MU	47.0	47.1
Dose Rate	600.0	0.0 MU/min
Time	10.7	4.8 sec

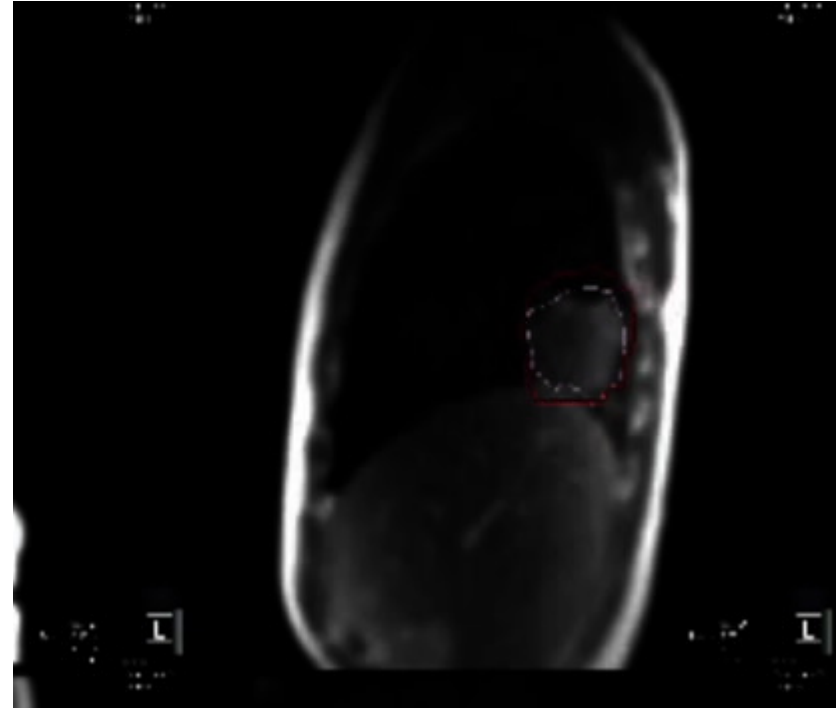
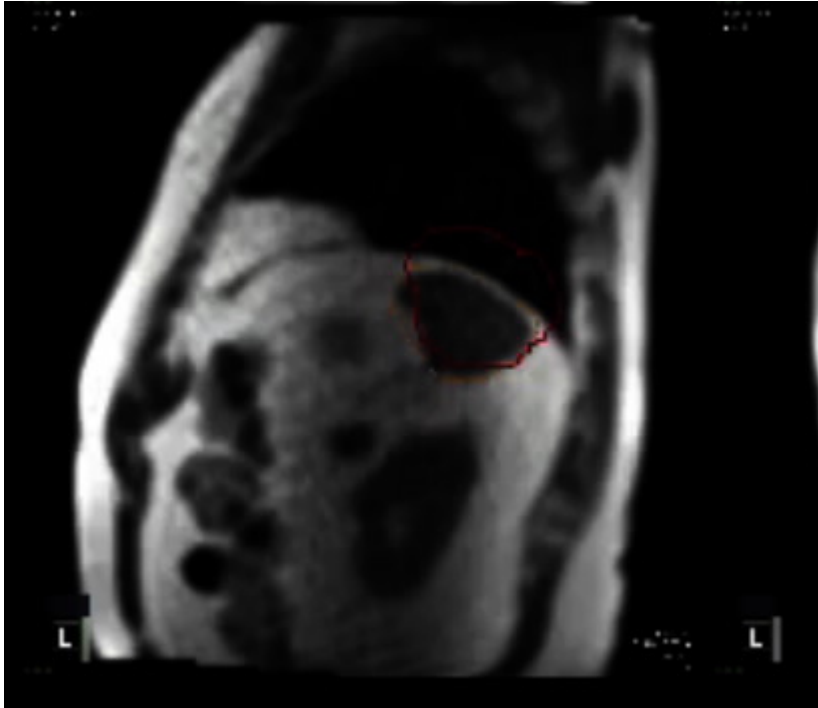
Total Fraction

Plan	Actual
MU	1798.9 / 109.2

Plan and Machine

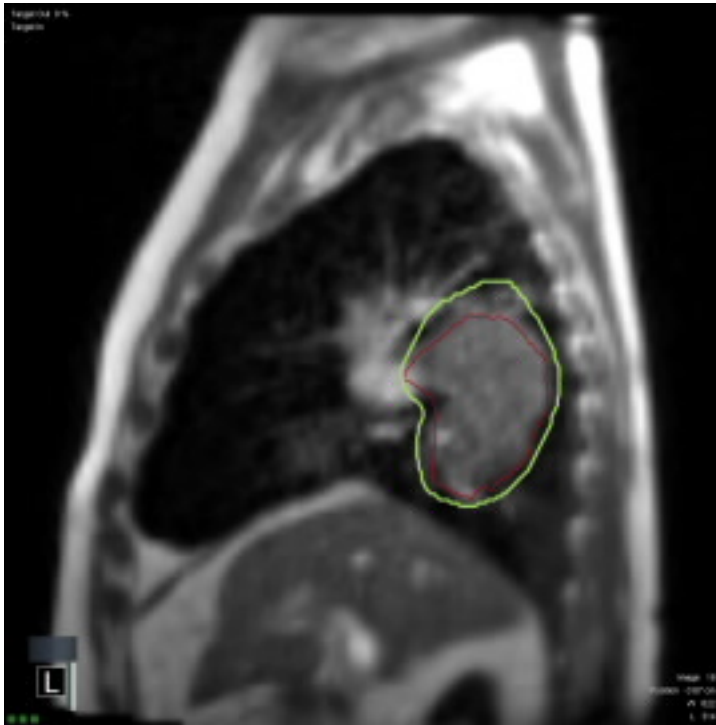
Plan Type	IMRT	Actual	Setup
Fraction Number	1 of 4	Gantry Angle	138.5 + / 55.4 +
Fraction Primary Dose	9.00 Gy	Couch Lateral	0.2 cm / 0.2 cm
Patient Orientation	Head First Supine	Couch Vertical	-17.6 cm / -17.6 cm

# Online Tumor Tracking

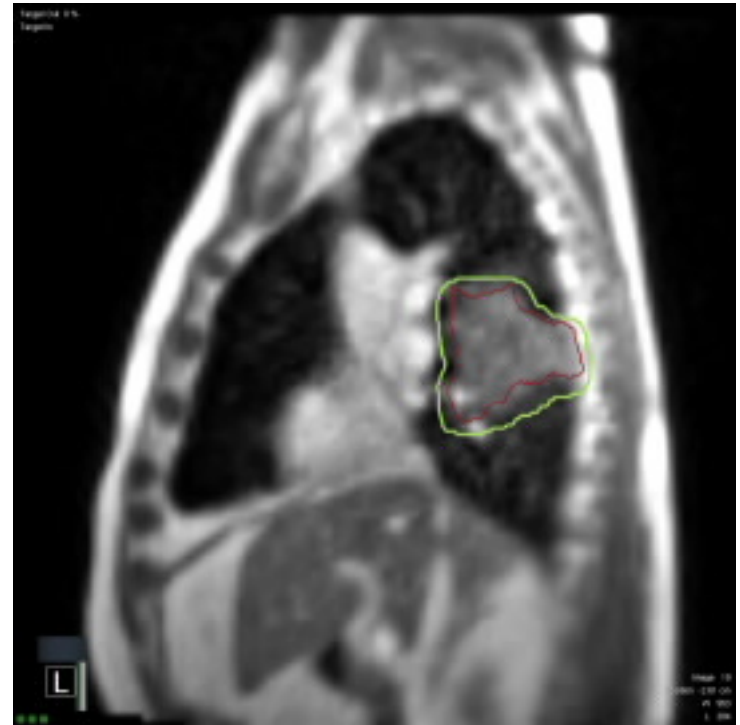


# Lung Cancer Adaptive Radiotherapy

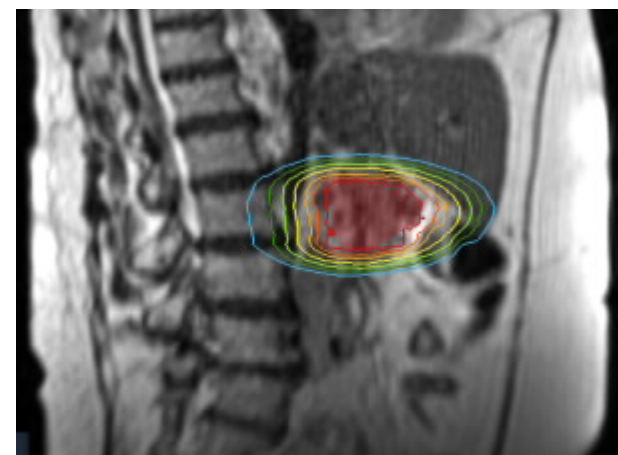
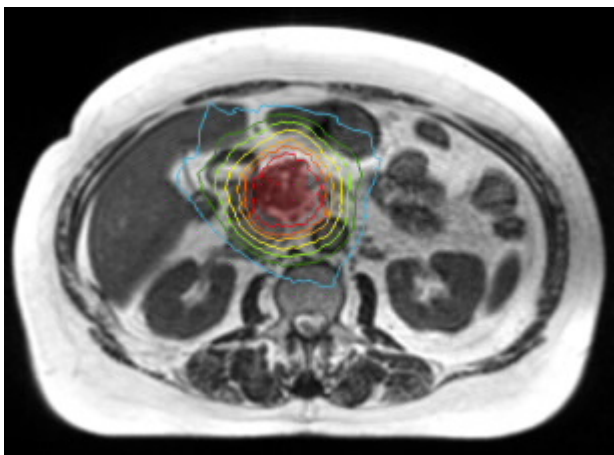
Fx 1



Fx 17

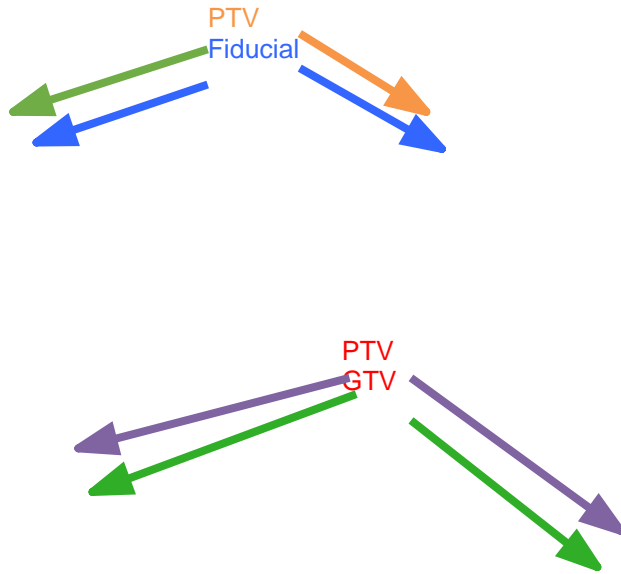


# Pancreatic Cancer Tumor Tracking



# Pancreatic Cancer Tumor Tracking

CBCT vs MRI IGRT



Real Time Online MRI  
Imaging

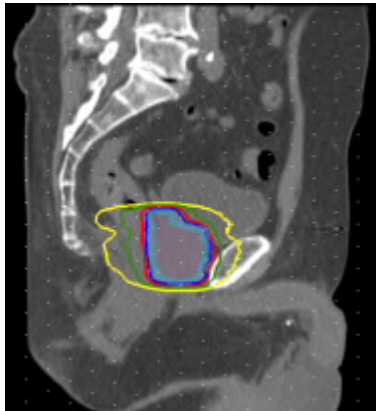
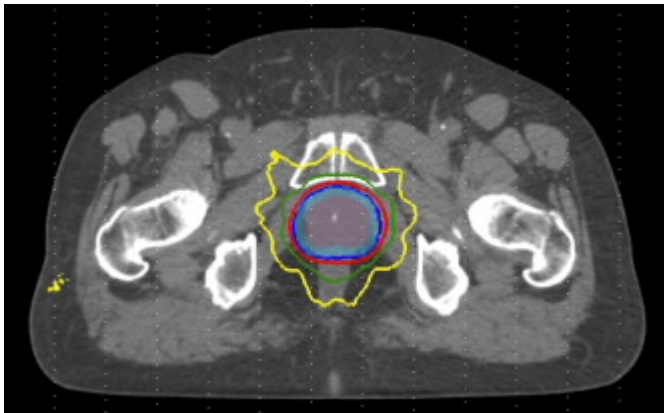


# Prostate Cancer SBRT

3625 cGy / 5 Fr

Real-Time Online  
Tracking

Planning CT



Flatulation during treatment  
and halting the treatment

# Teşekkürler



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