Radiation Oncology for the Cancer Registrar *All You Need to Know*

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Modern Oncology Treatment

Clinicians

- Medical Oncologists
- Radiation Oncologists
- Surgical Oncologists

Treatments

- Systemic therapy
- Radiation therapy
- Surgery & ablations

Eradicate tumor while sparing normal tissue

Eradicate Tumor while Sparing Normal Tissue

Radiation Biology

How dose interacts with cells

- Total Dose
- Dose fractionation



Radiation Physics

How dose is positioned in the body

- Dose delivery techniques & devices
- Patient Positioning



Patient flow through radiation treatment

- Consultation
- Additional diagnostic studies
- Simulation
- Treatment Planning
 - Target Volumes
 - Treatment techniques
 - Prescription writing
- Treatment
 - Equipment & Devices
 - Image guidance
 - Weekly management visits
- Follow Up

Treatment Planning & Target Volumes

Initial Consultation

Staging/Workup

Tumor Board

Evidence Based

Trials/Research

Simulation

Treatment Planning

On Treatment Visits

Portal Imaging

Follow-up



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Survivorship

Gross Primary Tumor in Piriform Sinus/Larynx



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Survivorship

Avoidance Structures

Parotid glands

Mandible

Cochleae

Brain

Optic nerves & chiasm

Spinal Cord

Pharyngeal constrictors

Upper esophagus

Submandibular glands

Oral cavity

Larynx

Initial Consultation

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Initial Consultation

Staging/Workup

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Evidence Based

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Simulation

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Follow-up



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Staging/Workup

Tumor Board

Evidence Based

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Simulation

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Portal Imaging

Follow-up

Survivorship

Avoidance Structures

Cumulative Dose Volume Histogram



DVH	Structure	Structure Status	Coverage [%/%]	Volume	Min Dose	Max Dose	Mean Dose	Modal Dose	Median Dose	Std Dev
_	Cochlea R	Approved	100.0/99.8	0.8 cm ³	386.8 cGy	943.6 cGy	636.0 cGy	507.9 cGy	621.4 cGy	127.2 cGy
_	Cochlea L	Approved	100.0 / 100.4	0.8 cm ³	423.7 cGy	1165.3 cGy	681.3 cGy	488.0 cGy	646.2 cGy	170.5 cGy
	GTV Primary	Approved	100.0 / 100.2	5.1 cm ³	7096.9 cGy	7464.5 cGy	7270.4 oGy	7262.1 cGy	7267.8 cGy	38.3 cGy
	Constrictors	Approved	100.0 / 100.1	8.3 cm ²	2273.8 cGy	4919.0 cGy	2981.7 cGy	3003.2 cGy	2947.7 cGy	324.1 cGy
			-							
DVH	Structure	Structure Status	Coverage [%/%]	Volume	Min Dose	Max Dose	Mean Dose	Modal Dose	Median Dose	Std Dev
	Larynx	Approved	100.0 / 100.0	13.0 cm ³	2234.1 cGy	5653.7 cGy	3681.4 cGy	4077.7 cGy	3709.8 cGy	721.5 cGy
_	Esophagus	Approved	100.0 / 100.0	19.4 cm ³	48.8 cGy	5849.6 cGy	2841.4 cGy	163.6 cGy	3731.6 cGy	2044.6 cGy
_	CTV Primary	Approved	100.0 / 100.0	20.9 cm ²	6592.0 cGy	7588.1 cGy	7284.8 cGy	7275.9 cGy	7283.3 cGy	59.6 cGy
	Parotid L	Approved	100.0 / 100.0	27.0 cm ³	820.6 cGy	6998.0 cGy	2574.1 cGy	970.9 oGy	1915.7 cGy	1615.9 cGy
	Parotid R	Approved	100.0 / 100.0	28.8 cm ²	731.4 cGy	7374.1 cGy	2562.8 cGy	823.0 cGy	2159.3 cGy	1510.7 cGy
	Brainstem	Approved	100.0 / 100.1	43.2 cm ³	156.8 cGy	4973.9 cGy	827.7 cGy	208.0 cGy	347.2 cGy	1070.4 cGy
	Spinal Cord	Approved	100.0 / 100.0	45.2 cm ³	35.8 cGy	4119.9 cGy	2410.4 cGy	87.9 oGy	2862.1 cGy	1322.8 cGy
_	Parotids R and L	Approved	100.0 / 100.0	55.8 cm²	731.4 cGy	7374.1 cGy	2568.3 cGy	867.3 cGy	2059.7 cGy	1562.6 cGy
	Mandible	Approved	100.0 / 99.9	80.9 cm ³	493.4 cGy	6568.0 cGy	3259.2 cGy	2860.0 cGy	3277.2 cGy	1181.0 cGy
	PTV Neck 6996	Approved	100.0 / 100.1	182.0 cm ³	3742.7 cGy	7605.1 cGy	7229.7 cGy	7267.1 cGy	7255.8 cGy	185.9 cGy
_	CTV Neck B	Approved	100.0 / 100.0	632.3 cm ²	4859.1 cGy	7548.3 cGy	6505.7 cGy	6206.9 cGy	6274.8 cGy	444.7 cGy
	PTV Neck 5940	Approved	100.0 / 100.0	966.2 cm ³	3323.8 cGy	7548.3 cGy	6404.2 cGy	6207.4 cGy	6243.7 cGy	473.2 cGy
	Brain	Approved	100.0 / 100.0	1557.4 cm ³	23.0 cGy	4913.9 cGy	196.9 cGy	38.6 cGy	88.9 cGy	413.7 cGy

External Beam Radiation Therapy Treatment Techniques

3-Dimensional Conformal

- Most "Standard" form of EBRT
- Three-dimensional models made through contouring CT slices
- Beams aimed from different angles for best dose distribution
- Less physics-intensive than IMRT



Intensity Modulated Radiation Therapy (IMRT)

- Technique to improve PTV coverage while lowering avoidance structure dose
- Involves input of Goals and Constraints into treatment planning computer – Inverse planning
- Treatment planning computer optimizes beam angles and dose accumulation in 3D space
- Results in concave dose distributions and steep dose gradients
- Plans are then tested by medical physicist on linear accelerator to ensure plan can be delivered as expected

Intensity Modulated Radiation Therapy (IMRT)



Variations of IMRT – Delivery Methods

- Static Gantry
- VMAT (volume modulated arc therapy)
 - RapidArc (Varian)
 - Intellibeam (Elekta)
- Helical (TomoTherapy)



SBRT/SABR

- Stereotactic Body Radiation Therapy
- Stereotactic Ablative Body Radiation
- Large doses per fraction
- Between 1 and 5 fractions
- Small tumor volumes only
- Lung, liver, spine, kidney, prostate, and others



SRS

- Stereotactic Radiosurgery
- One fraction only
- Small tumor volumes only
- Brain metastases, some benign masses



Electrons

- Charged sub-atomic particles
- Penetrate to a relatively shallow depth then stop
- Skin cancers, breast cancer boosts



Other Treatment Techniques

- Protons
- Neutron
- Carbon Ion
- Brachytherapy

Radiation Prescriptions

Radiation Prescriptions – Required Elements

- Target volume(s)
 - PTVs (Planning Target Volumes)
 - Visible tumors
 - At-risk spaces
- Dose per fraction
- Number of fractions
 - 6000 cGy = 200 cGy x 30 fractions
- Total Dose
 - Additive in sequential volume reductions
 - Maximum listed dose in simultaneous integrated boost

- Treatment frequency
 - QD, BID, TID, TIW, etc.
- Treatment Technique
 - 3D, IMRT, electrons, brachytherapy
- Beam energy
 - e.g. photons: 6 MV, 15 MV, 23 MV
 - e.g. electrons: 6 MeV, 9 MeV, 12 MeV
- Image-guidance technique (IGRT)
 - kV imaging
 - Cone-beam CT (CBCT)
 - Surface tracking
- Special techniques
 - Respiratory gating
 - Deep-inspiration breath hold (DIBH)
 - Surface bolus

Radiation Prescriptions – Additional Factors

Additional Factors

- Target volume reductions
 - aka "Boost"
- Re-simulation & re-planning
 - Same Phase if TVs do not change
- Multiple sites simultaneously
- Multiple modalities
- Concurrent systemic therapy
- Special set-up techniques

Within the STORE

- Each Phase is defined by
 - Target volume
 - Fraction size
 - Modality
 - Treatment technique
- Phases may be sequential or simultaneous
- New Phase if any of the above change

Variations of Multi-Phase IMRT Prescriptions

- Sequential volume reductions
 - Fraction number varies by target volume
 - Fraction size usually the same for all targets
 - Dose variation by exclusion of lower risk volumes from higher dose plans
 - Reported as separate phases
- Simultaneous integrated boost (SIB)
 - Fraction number the same for all targets
 - Fraction size varies by target volume
 - Delivered in one plan
 - Still reported as separate phases



Radiation Prescriptions – Sequential IMRT

Dx: Malignant neoplasm of upper-outer quadrant of right female bro									Close		
Course: 1									<u>A</u> dd		
» Site Technique M		Modality	Act Rx Dose Pattern					Act	Rx Dose Rx	<u>C</u> hange	
Right Chestwall & L R Chestwall & R Ax Final Boost R CW	MRT - RapidArc IMRT - RapidArc IMRT - RapidArc	x06 x06 x06	25 3 5	25 3 5	180 cGy 180 cGy 200 cGy	Daily Daily Daily			4,500 cGy 540 cGy 1,000 cGy	4,500 cGy 540 cGy 1,000 cGy >	Delete Dosimetry
Rx Site: Right Chestwall & LN Status: Approved KEL 9/11/2019 View Fractions: By Course Technique: IMRT - RapidArc Number Fractions: By Course Medalibr: x06 M											
Dose Spec: Plar						Week	[S M T W	TFSA	Note	
Rx Dose	mber of Fractiona actions Pattern	tion	Status			1			4 5 9 10	Plan Docs	
4,500 cGy	180 cGy	y 25 Daily			Fractions Treated 5				16 17 18	19 20 24 25	S <u>ī</u> atus
6 26 27 28 29 30 7 31 32 33											
Dose Limits		Pattern: Daily IGRT KV Imaging									
Total Cum:	Co	omment:	Boost	to follow						Fx Notes	
Radiation Rx is View Only											

Radiation Prescriptions – Simultaneous Integrated IMRT

	Dx:	IVA: Right Malign	ant neoplasr	n of vallecula	p16 positi	ve							Close
	Squamous cell carcinoma, NOS Course: 1								Course: 1		<u>A</u> dd		
» Sit	e	Technique	Mod	lality	t Rx	Fra	Pat	is tern		Act	Rx Dos	(<u>D</u> hange
PT	V Neck 6996	IMRT - Rap	oidArc x06		33 33	212 cGy	Dai	y		6,996 cGy	6,996 cGy		Delete
													a simatar
													osimeu <u>v</u>
<											>	-	±
	Rx Site:	PTV Neck 6996		Status:	Approved	JGB 12/05/	2017	,	<u>V</u> iew Fracti	ions: By Cour	se 💌		
	Technique: IMRT - RapidArc Number Fractions: By Course												
	Modality:	x06							_	1.4	_		
	Dose Spec:	Plan						Week		SIMITIW	TFSA		Note
	Rx	Fractional	Number of	Fractionation	n Sta	atus		1		1 2 3	4 5	PI	an D <u>o</u> cs
	Dose	Dose	Fractions	Pattern				3		11 12 13	3 14 15		Status
	6,996 cGy	212 cGy	33	Daily	Fra	actions Treated	1	4		16 17 18	24 25		_
								6		26 27 28	29 30		
											· · · · ·		
Dose Limits				Pattern: CBCT aligned to Pharyngeal Air daily									
Total Cum:			Comment: PTV Neck 5445 @ 165/day concurrent chemo, Dr. Ambinder								F	v Notes	
													X110105
						Ra	diati	on Rx is Viev	v Only				

Finding Prescription Information

- Consultation Notes
- Radiation prescriptions within Aria or Mosaiq EMRs
- Physics notes
- Weekly on-treatment notes
- Treatment plan from treatment planning system stored in EMR
- Treatment summaries
- Ask physician, dosimetrist, or physicist

External Beam Planning	
External Beam Planning 13.6.30	Florida Oncology Tavares, Tavares, FL
Fields of isocenter: 2.1 2.2 2CBCT	
Couch shift from reference setup position:	
Shift (cm): 1.02	3.85 5.54
Direction: Right	Up Out
-	
Dose Prescription	
Target Volume:	PTV Rectum 5040
Plan Normalization Value:	100.0 %
Plan Normalization Method:	No plan normalization
Prescribed Dose Percentage:	100.0 %
Primary Reference Point:	PTV Rectum 5040
Relative Dose at Primary Reference Point:	100.0 %
Number of Fractionations:	1
Fractionation:	F1
Prescribed Dose:	540.0 cGy (180.0 cGy / fraction)
Dose at primary reference point:	540.0 cGy (180.0 cGy / fraction)
Number of Fractions:	3
Calculation Models and Options	
Photon Volume Dose	
Calculation Model:	AcurosXB_13623
Option Value	Option Name
Bone	AutomaticHighDensityMaterial
0.25	CalculationGridSizeInCM
Dose to medium	DoseReportingMode
100% to isocenter	FieldNormalizationType
ON 0.50	Heterogeneity-correction
0.50	Naximumvutomatichignuensityvolumeinuma
VMAT Optimization	r mitovoovereenenen
Calculation Model:	PO 13623
Option Value	Option Name
Ön	AirCavityCorrection
On	InhomogeneityCorrection
40	SmoothX
30	SmoothY
2.1 ()	
Machine ID:	TB_R1
Machine Model:	TDS
Machine Last Modified:	Tuesday, March 29, 2016 12:20:02 PM
Machine Scale:	vanan IEG
Energy Mode:	bX
Dose Rate:	ADC
Technique: Service Aria Distance (SAD)	ARG 100.0 cm
autroennus-unstance (anu);	TOUR ON

External Beam Radiation Therapy Equipment

External Beam Radiation Therapy

Equipment

- Linear Accelerator (Gantry Based)
- TomoTherapy
- ViewRay MRIdian
- CyberKnife
- Gamma Knife
- Mobetron
- Particle therapy machines

<u>Techniques</u>

- 3D Conformal
- Intensity Modulated (IMRT)
 - Static gantry
 - VMAT
- SBRT/SABR
- SRS
- Electron beam
- Proton
- Neutron
- Carbon Ion

Linear Accelerator – Gantry Based



- Most common RT delivery system
- Many treatment modalities
- Great versatility in treatment sites

Linear Accelerator – Gantry Based



Modalities

• 3D conformal

• IMRT

- Static gantry
- VMAT
- SBRT/SABR
- SRS
- Electron beam

Linear Accelerator



- Generates radiation via electricity
- Accelerates electrons to speed of light to impact tungsten target
- Photons generated by impact
- Photons directed into patient
- Target removed to treat with electrons

Linear Accelerator – Gantry Based



- Some Brand Names
- Varian TrueBeam
- Varian Trilogy
- Varian EX/iX
- Varian 2100
- Elekta Synergy HD
- Elekta Infinity HD
- Elekta Versa HD

Linear Accelerator – Helical



Brand Names

- Accuray TomoTherapy
- Varian Halcyon

Modalities

- IMRT (helical)
- 3D Conformal

- Rotating linear accelerator
- Photons only

Linear Accelerator – View Ray MRIdian



Modalities

• IMRT

- Particulars
- Rotating linear accelerator
- Photons only
- Built-in MRI for IGRT & adaptive replanning

Gamma Knife



ModalitiesSRS (Gamma Knife)

- Heads only
- Screw-on headframe
- Neurosurgeon involved
- Cobalt-60 sources (photons)
- One session
- Often multiple targets

Gamma Knife



ModalitiesSRS (Gamma Knife)

- Heads only
- Screw-on headframe
- Neurosurgeon involved
- Cobalt-60 sources (photons)
- One session
- Often multiple targets

CyberKnife



Modalities

- SRS (robotic)
- SBRT/SABR

Particulars

- Miniature linear accelerator on robotic arm
- Stereotactic treatments only (5 fractions or less)

• Photons

Proton Therapy



Modalities

- 3D (protons)
- IMPT (protons)

- Eliminates exit dose
- Expensive
- Limited availability
- Well suited for brain, spinal cord, children
- Sometimes combined with photons

Proton Therapy



Protons

X-rays

Neutron Therapy



Modalities

3D

- Only 3 centers in US
- Primarily used for salivary gland tumors
- More skin reaction
- More tissue fibrosis

Mobetron



Modalities

• Electrons

- Intraoperative radiation delivery
- Single fraction
- Breast & pancreas most common sites

Superficial / Orthovoltage



Modalities

• kV (low energy) photons

- Non melanoma skin cancers
- Minimal shielding required
- Used most commonly by dermatologists
- Often without radiation oncology involvement

Brachytherapy

Brachytherapy

- Use of physical radioactive material to deliver "close therapy"
- Doses cannot be added to EBRT doses for coding purposes
- HDR (High dose rate)
 - Contura/SAVI/Mammosite
 - Vaginal cylinder
 - Tandem & Ovoid/Tandem & Ring
 - Prostate
 - Skin applicator
 - Custom applications

- LDR (low dose rate)
 - Prostate seeds
 - GYN intracavitary implants
 - GYN interstitial implants
 - Retinal plaques
- Radiopharmaceuticals
 - lodine-131
 - Strontium
 - Radium-223
 - Yttrium-90
 - Lutathera

High Dose Rate (HDR) Brachytherapy



Modalities

- HDR Intracavitary
- HDR Interstitial
- HDR Surface

- Treatments take minutes
- Multiple fractions
- Iridium-192 radioactive source
- Uses temporary implants
- Cervix, endometrial, prostate, breast, skin, head & neck extremities

HDR Brachytherapy - Intracavitary







Accelerated partial breast irradiation

- MammoSite
- Contura
- SAVI

Tandem & ovoid

• Cervix

Vaginal cylinder

- Endometrial cancer
- Vaginal cancer

HDR Brachytherapy - Interstitial



Soft tissue implants

- Breast
- Extremity
- Head & neck



- Prostate
 - Often after IMRT



Gynecologic

- Endometrial cancer
- Vaginal cancer
- Cervix
- After EBRT

HDR Brachytherapy - Surface



Freiburg flap

• Non-melanoma skin



• Non-melanoma skin

Leipzig applicator



AccuBoost

- Breast cancer
- After whole breast EBRT

Low Dose Rate (LDR) Brachytherapy



Modalities

- LDR Interstitial
 - Prostate seeds
 - Gynecologic
 - Head & Neck
- LDR Intracavitary
 - Gynecologic

- Seeds stay in for at least days
- One fraction
- Permanent in prostate cancer
- Temporary in most other applications
- Iodine-125
- Palladium-103
- Cesium-131

Radiopharmaceuticals

- Iodine-131
 - Papillary thyroid cancer
- Strontium-89 & 90
 - Bone metastases
- Radium-223 (Xofigo)
 - Prostate bone metastases
- Yttrium-90 ibritumomab (Zevalin)
 - Non-Hodgkin lymphoma
- Samarium-153 (Quadramet)
 - Osteoblastic bone metastases
- Lutetium-177 (Lutathera)
 - Gastroenteropancreatic neuroendocrine tumors (GEP-NETs)



Summary - Radiation Modalities

External Beam

- Photons
 - 3-dimensional conformal
 - Linac
 - Source-based
 - IMRT
 - Static gantry
 - VMAT
 - Helical
 - SRS
 - GammaKnife
 - CyberKnife
 - Linac based
 - SRT
 - SBRT/SABR
 - Orthovoltage/Superficial
- Electrons
- Protons
- Neutrons

Brachytherapy

- HDR
 - Contura/SAVI/Mammosite
 - Vaginal cylinder
 - Tandem & Ovoid/Tandem & Ring
 - Prostate
 - Skin applicator
 - Custom applications
- LDR
 - Prostate seeds
 - GYN intracavitary implants
 - GYN interstitial implants
 - Retinal plaques
- Radiopharmaceuticals
 - Iodine-131
 - Radium-223
 - Samarium-153
 - Yttrium-90
 - Lutetium-177

Summary - STORE Coding Principles

• Phases

- Radiation Prescription
- Total Dose
 - Sequential vs Simultaneous
- Phase N Primary Target Volume
 - Derived from Radiation Prescription
- Brachytherapy
 - No addition of EBRT and brachytherapy doses
- Documentation

Questions?

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