Implementing SBRT Protocols: A NRG CIRO Perspective

Ying Xiao, Ph.D.

What is NRG Oncology?

- One of five new NCI-supported National Clinical Trials Network (NCTN) groups.
- NCTN officially started March 1, 2014.
- Founded as a group by **N**SAPB, **R**TOG, & **G**OG.
- The NSABP, RTOG, & GOG Foundations will conduct clinical trials independent of NCI.
- NRG Oncology has largest trial portfolio & highest projected enrollment of all 5 groups.

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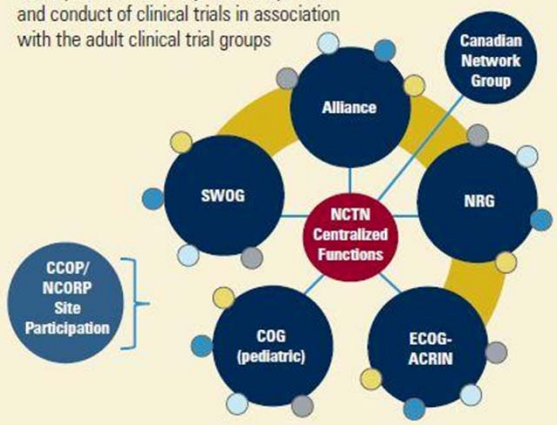
NCTN Structure

Fig. 1.

- 5 U.S. groups (4 adult and 1 pediatric) and 1 Canadian group
- More centralized functions for operational efficiencies
- Will optimize use of scientific innovations
- LAPS provide leadership in development and conduct of clinical trials in association with the adult clinical trial groups



LEGEND:

- Centralized Functions:
  - Centralized Institutional Review Board
  - Cancer Trials Support Unit
  - Radiotherapy/Imaging Cores
  - Common Data Management System Central Hosting
- 30 Lead Academic Participating Sites (LAPS)
- Operations
- Statistics and Data Management
- Tumor Banks
- Member Sites

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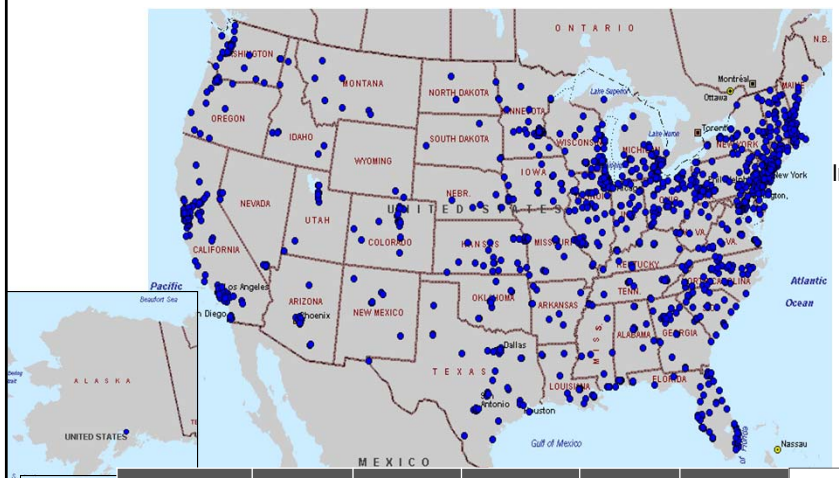
Group Enrollment 2006-2010



3,100 Institutions

14,000 Investigators

About 25,000 pts enrolled on tx trials annually

Trials	FY2006	FY2007	FY2008	FY2009	FY2010
All Phases: Treatment Trials	27,667	24,715	25,784	29,285	23,468

Accrual Distribution:
Phase 3: 83.4%
Phase 2: 15.1%
Phase 1/Pilot: 1.5%

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5 NRG Oncology Specific Aims

Improve the lives of adult patients with **localized or locally advanced cancers** through the conduct of high quality NCI-supported multi-institutional clinical trials;

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5 NRG Oncology Specific Aims

Conduct practice-defining research for the major **gender-specific malignancies** (breast & gynecologic cancers & prostate cancer) while capitalizing on common biologic features and interactive research opportunities among these diseases;

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5 NRG Oncology Specific Aims

Investigate new developments in **medical technology**, including radiation oncology, imaging, surgical technology, & IT, for opportunities to advance the care of patients with localized / locally advanced cancers;

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5 NRG Oncology Specific Aims

Integrate and expand the legacy groups' **translational science** programs to better inform biomarker- and biologic pathway-defined approaches to risk stratification, investigational therapy assignment, & clinical trial decision-making;

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5 NRG Oncology Specific Aims

Selectively expand GOG's **developmental therapeutics** program to NRG's other six cancer disease site committees to further strengthen the selection of investigational approaches for phase II & III trials.

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NRG Oncology
Center for Innovation in Radiation Oncology
(CIRO)

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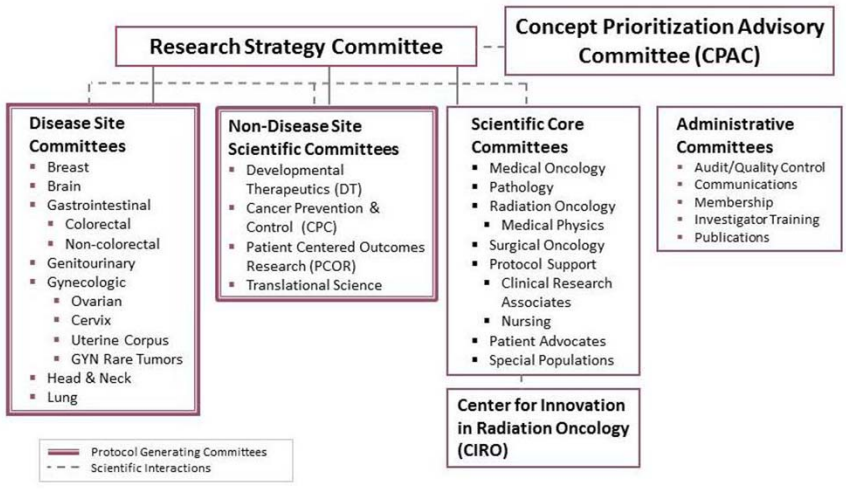
NRG Committee Structure



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Aims of CIRO

- Promote innovative RT research within all NCTN
- Accelerate testing new rad onc innovations in NCTN
- Facilitate innovation in all appropriate protocols
- Foster intergroup & protocol harmonization
- Reduce timelines for development of new protocols
- Improve the clarity of NCTN protocols

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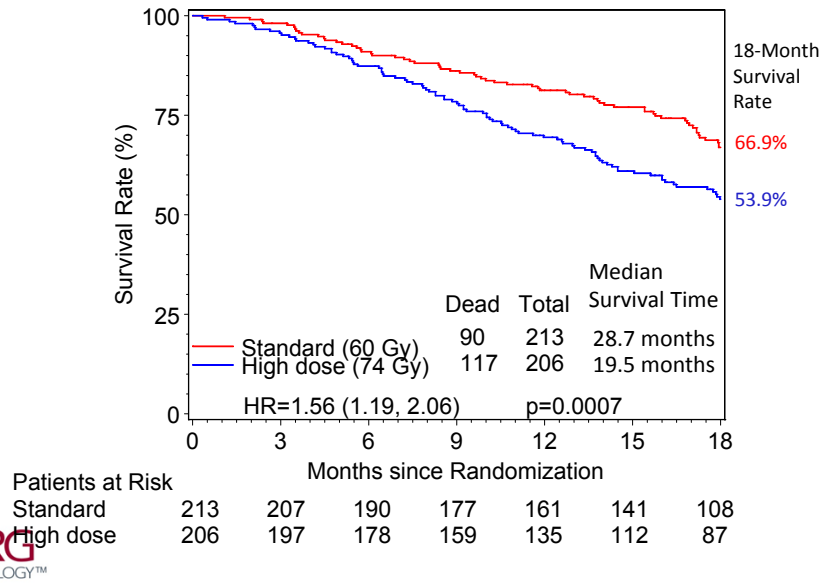
NRG/RTOG 0617: Survival by RT Dose



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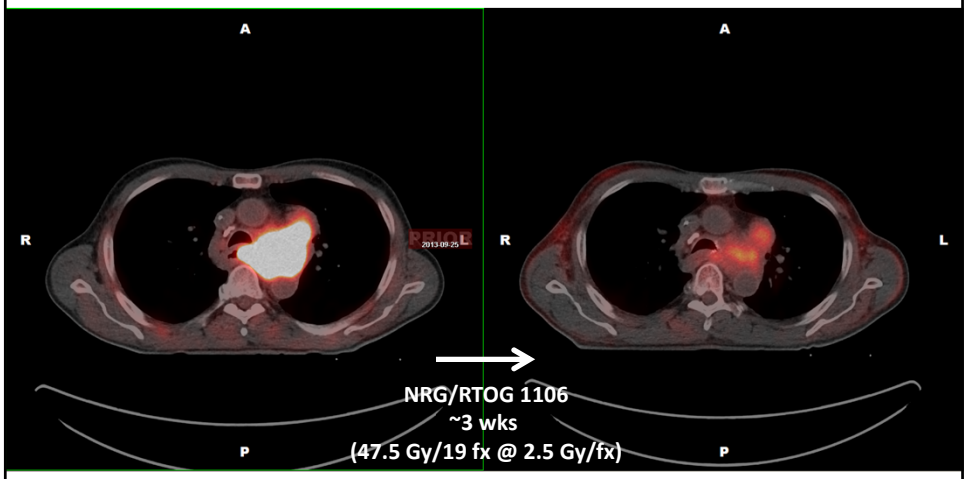
PET-Adapted Radiation Therapy



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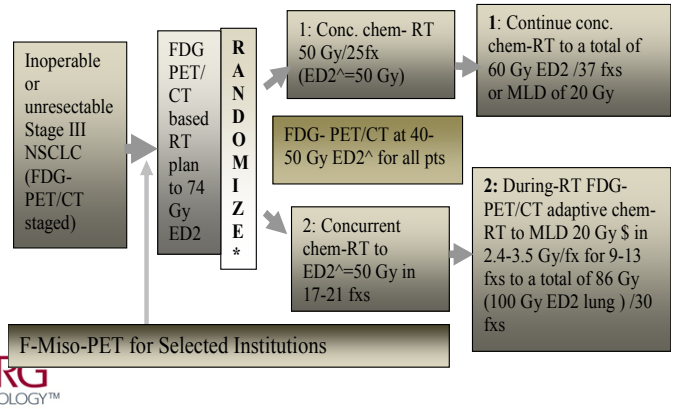
NRG/RTOG 1106-Adaptive RT for Stage III NSCLC Pts

NRG/RTOG 1106 tests the efficacy of during-RT PET-MTV based individualized radiation dose escalation.



RTOG 0617
Uniform RT dose prescription

Experimental arm:
Individualized adaptive RT

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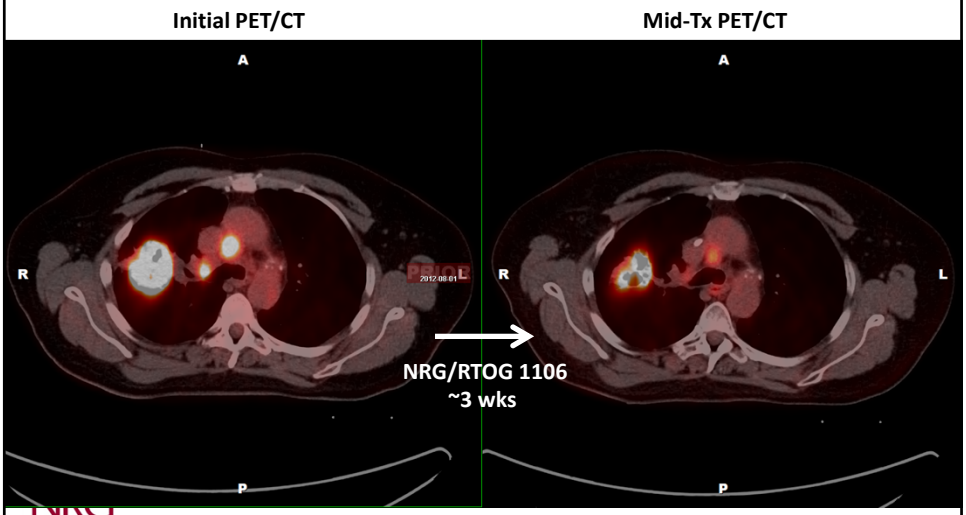
PET-Adapted Radiation Therapy



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Proton Beamline

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NRG/RTOG 1308: Phase III Randomized Trial Comparing Overall Survival after Photon vs Proton Chemo-RT for Stage II-IIIB NSCLC

Stratify
Stage
1.IIIA
2.IIIB

GTV
1.<= 130 cc
2.>130 cc

Histology
1.Squamous
2.Non-Squamous

RANDOMIZATION

Arm 1
Photon: Highest achievable dose between 60-70 Gy at 2 Gy, once daily plus platinum-based doublet chemotherapy

Arm 2
Protons: Highest achievable dose between 60-70 Gy (RBE) at 2 Gy (RBE) once daily plus platinum-based doublet chemotherapy

Arms 1 and 2: Consolidation Chemotherapy x 2 is allowed

Plan must meet dose and volume constraints of all OARs (very different from other trials)

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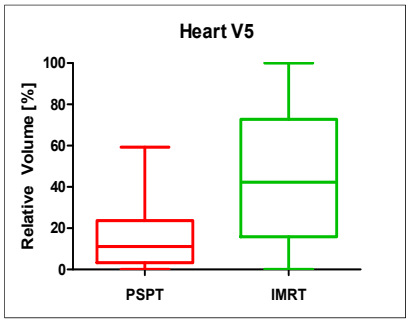
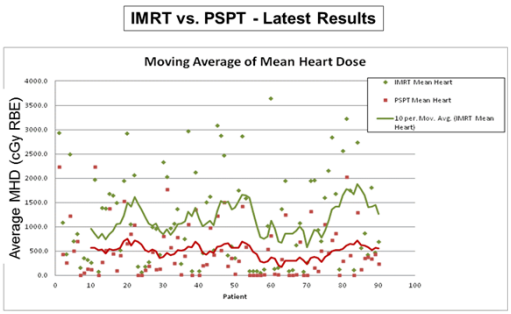
Heart Dose: Protons vs IMRT





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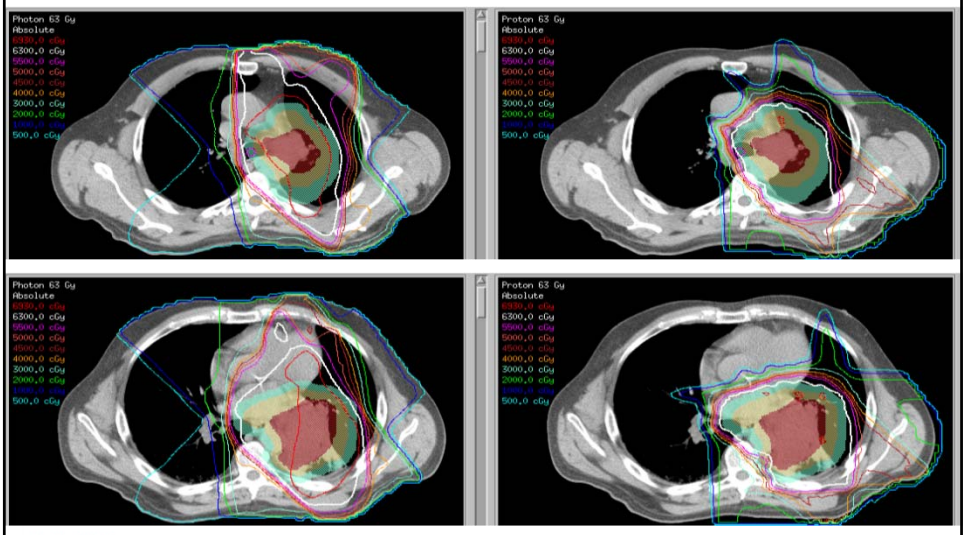
3D vs Proton for NSCLC

Photon 3D-CRT

Proton



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NRG Oncology Summary

- Amazing Adaptation of NRG Oncology Members to New System!
- Trials in NCTN Limited by Available Resources
- What are Unintended Consequences of Transition?
- Great Need for Resources in Project Development
- CIRO will be a Critical Resource for NRG and NCTN

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SBRT Protocols-Past&Present Examples

Published in final edited form as:
JAMA. 2010 March 17; 303(11): 1070–1076. doi:10.1001/jama.2010.261.

Stereotactic Body Radiation Therapy for Inoperable Early Stage Lung Cancer

Robert Timmerman, M.D., Rebecca Paulus, B.S., James Galvin, Ph.D., Jeffrey Michalski, M.D., William Straube, Ph.D., Jeffrey Bradley, M.D., Achilles Fakiris, M.D., Andrea Bezjak, M.D., Gregory Videtic, M.D., David Johnstone, M.D., Jack Fowler, Ph.D., Elizabeth Gore, M.D., and **Hak Choy, M.D.**

Abstract

Context—Patients with early stage but medically inoperable lung cancer patients have a poor rate of primary tumor control (30-40%) and a high rate of mortality (3-year survival 20-35%) with current management.

Objective—To evaluate the toxicity and efficacy of stereotactic body radiation therapy in a high risk population of patients with early stage but medically inoperable lung cancer.

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NRG-BR001
ClinicalTrials.gov NCT02206334

A Phase 1 Study of Stereotactic Body Radiotherapy (SBRT) for the Treatment of Multiple Metastases

This trial is sponsored by the National Cancer Institute (NCI) and will be led by NRG Oncology.

Study Team

Steven Chmura, MD, PhD/Radiation Oncology
University of Chicago
5840 S. Maryland Ave, MC9006
Chicago, Il 60637
773-702-0817/Fax:773-834-7233
schmura@radonc.uchicago.edu

Radiation Oncology Co-Chair
Joseph K. Salama, MD
Duke University Medical Center
Box 3085
Durham, NC 27710
919-668-7338/Fax 919-668-7345
joseph.salama@duke.edu

Lung Committee Co-Chair/Radiation Oncology
Clifford Robinson, MD
Washington University in St. Louis
4921 Parkview Place, Box 8224
St. Louis, MO 63110
314-362-8567/Fax:314-362-7769
crobinson@radonc.wustl.edu

Genitourinary Committee Co-Chair/Radiation Oncology
Thomas M. Pisansky, MD
Mayo Clinic

Medical Oncology Co-Chair
Virginia Borges, MD
University of Colorado
Anschutz Medical Center
19801 E 17th Avenue, RC1S 8112
Aurora, CO 80045
303-949-9964/Fax:720-848-1774
virginia.borges@ucdenver.edu

Medical Physics Co-Chair
Hania Al-Hallaq, PhD
University of Chicago
5758 S. Maryland Ave., MC9006
Chicago, IL 60637
773-702-3309/Fax:773-834-7233
hal-hallaq@radonc.uchicago.edu

Medical Physics Co-Chair
Martha Matuszak, PhD
University of Michigan
1500 E. Medical Center Dr.
Ann Arbor, MI
734-232-6195/FAX 734-936-7859
marthamm@med.umich.edu

Senior Statistician
Kathryn Winter, MS

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NRG BR001 Schema

SCHEMA

Patients with metastatic breast, adenocarcinoma of the prostate or non-small cell lung cancer with ≤ 4 metastases; all metastases not resected must be amenable to SBRT
See Section 3.0 for details

↓

REGISTER

↓

SBRT (in 3 or 5 fractions) to all existing metastases in 1-3 weeks
See Table 6-1 in Section 6.1 for dose levels and Table 13-1 in Section 13.3 for Dose Limiting Toxicities (DLTs)

See Section 5.0 for pre-registration requirements and Section 6.0 for details of radiation therapy planning and delivery

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Legacy RTOG Protocol TOC

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NRG Protocol TOC

Table Of Contents

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The Process – SBRT template

Radiation Therapy Section Template for NRG SBRT Protocols

Last Update: 5/6/15 by Martha Matuszak and Indrin Chetty

Note: The goal of this new table format for SBRT protocols is to simplify and streamline protocol development as well as make it easier for sites to find relevant information in the protocol. This template was designed for lung SBRT, as part of the mission from lung and SBRT work group, NRG medical physics committee, Center for Innovation in Radiation Oncology (CIRO)

Instructions for Protocol PIs: Yellow Highlighted Text should be edited to be protocol specific.

5.2 Radiation Therapy

Radiation Therapy Schema

INSERT PROTOCOL SPECIFIC FIGURE DETAILING THE SCHEMA WITH RELEVANT RT INFORMATION AND TIMELINE

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5.2.1 Treatment Technology Requirements

General treatment technology requirements for SBRT are given in Table 5.2.1A. Questions regarding appropriate technology for this protocol can be directed to the protocol PI or medical physics co-chair.

Table 5.2.1A Summary of Treatment Technology Requirements

Technology	Requirement	Comments
Beam Modality	MV Photons	Cobalt-60 & Linac Allowed; Charged particle beams (including electrons, protons, and heavier ions) are not allowed
Beam Energy	1 to 18 MV	Minimize use of high energy in lung. 6 MV or lower energies should be predominately used in low-density tissue.
Treatment Technique	3DCRT (static, arc) or intensity modulated techniques (IMRT, VMAT)	Tomographic and robotic techniques allowed.
Image Guidance	Treatment Machine must be equipped to provide daily image guidance. The minimum required image guidance techniques as a function of treatment techniques are given in Section 5.2.11.	Non-ionizing guidance is allowed, but secondary image verification is required

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5.2.2 Immobilization and Simulation

Table 5.2.2A Summary of General Simulation Guidelines

Topic/Parameter	Guideline
Immobilization	Proper immobilization with appropriate clinical devices to ensure reproducibility is required. Patient discomfort should be minimized.
Motion Control	Recommended in cases where the extent of motion and patient geometry may result in a violation of dosimetric constraints to normal tissues. Institutions should use their clinical judgment when determining which patients are appropriate for a motion management technique.
CT Slice Thickness	2 mm or less is recommended. No more than 3 mm shall be used in the vicinity of the target. PTV size should be taken into consideration when choosing the slice thickness. Slices of 1-2 mm should be used for tumors that are 1 cm or less in the largest dimension.
Use of Contrast	IV and/or oral contrast can be used at the clinical discretion of the treating institution. It is recommended to perform a non-contrast enhanced CT for planning. For how to handle treatment planning on a contrast CT, please see the treatment planning section.

To simplify the simulation and planning process, Table 5.2.2B highlights the recommended and minimum requirement for motion assessment, treatment planning imaging, and PTV margins for all SBRT protocols.

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Table 5.2.2B Motion Assessment Guidelines for Simulation

Treatment Technique	Recommended Method for Motion Assessment During Simulation	Minimum Method for Motion Assessment During Simulation	Scan(s) Required for Treatment Planning	Additional Instructions
Free breathing treatment using an ITV approach, including abdominal compression	4DCT	CT scans at normal inhale and exhale positions	Average/Untagged scan from 4DCT for dose calculations; MIP may be desirable to aid ITV definition; If 4DCT not available, planning scan should be at normal exhale	A free breathing non-4DCT scan is not appropriate
Gating with a gating window	4DCT	Exhale CT plus fluoro (free-breathing + fluoro strongly discouraged due to baseline shift)	Reconstructed average of gating window scans if 4DCT or normal exhale scan	Exhale recommended since it gives the most conservative measure of lung dosimetry
Gating with breath hold (i.e. ABC)	Reproducibility of breath hold confirmed (examples: multiple low dose scans over tumor, repeat fluoroscopy or scout images)	N/A	Scan in breath hold position	Inhale recommended since it maximizes lung volume
Tracking	4DCT or breath hold CT	N/A	4DCT or breath hold CT	Need to know tumor trajectory

5.2.3Imaging for Structure Definition, Image Registration/Fusion and Follow-up

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Free-Breathing, MIP or AVE?

TABLE II. Dosimetric parameters for PTVs collected in FB plans, MIP plans, and AIP plans. Other dosimetric parameters with no significant changes were not listed here.

	Plan	Mean (Gy)	Standard error (Gy)	Comparison	*P* value
D_{max}	FB	54.4	8.6	FB vs MIP	0.116
	MIP	54.8	8.7	MIP vs AIP	0.132
	AIP	54.5	8.5	FB vs AIP	0.522
D_{min}	FB	44.0	6.3	FB vs MIP	<0.001
	MIP	45.0	6.5	MIP vs AIP	0.006
	AIP	44.4	6.3	FB vs AIP	0.003
D_{mean}	FB	50.3	7.1	FB vs MIP	0.002
	MIP	50.9	7.3	MIP vs AIP	0.008
	AIP	50.4	7.1	FB vs AIP	0.017
D95	FB	47.3	6.3	FB vs MIP	0.001
	MIP	48.1	6.5	MIP vs AIP	0.006
	AIP	47.5	6.4	FB vs AIP	0.003
D90	FB	48.0	6.4	FB vs MIP	0.001
	MIP	48.7	6.6	MIP vs AIP	0.006
	AIP	48.2	6.4	FB vs AIP	0.010
CI	FB	0.71	0.09	FB vs MIP	0.010
	MIP	0.67	0.11	MIP vs AIP	0.111
	AIP	0.69	0.09	FB vs AIP	0.002
TV_{PD}	FB	49.9	33.9	FB vs MIP	0.694
	MIP	50.1	33.7	MIP vs AIP	0.437
	AIP	49.6	33.9	FB vs AIP	0.035
V_{PD}	FB	66.4	42.1	FB vs MIP	0.070
	MIP	69.5	40.7	MIP vs AIP	0.154
	AIP	67.0	41.9	FB vs AIP	0.147

TABLE III. Dosimetric parameters for lungs minus PTV collected in FB plans, MIP plans, and AIP plans.

	Plan	Mean (cm^3)	Standard error (cm^3)	Comparison	*P* value
Abs. V5	FB	603.9	336.0	FB vs MIP	<0.001
	MIP	550.7	320.5	MIP vs AIP	<0.001
	AIP	603.0	337.5	FB vs AIP	0.860
Abs. V10	FB	323.7	182.9	FB vs MIP	<0.001
	MIP	304.0	180.4	MIP vs AIP	<0.001
	AIP	324.5	186.5	FB vs AIP	0.797
Abs. V20	FB	167.7	117.3	FB vs MIP	0.008
	MIP	160.1	114.5	MIP vs AIP	0.005
	AIP	167.7	118.7	FB vs AIP	0.976
Abs. V30	FB	91.9	73.1	FB vs MIP	0.078
	MIP	89.2	71.8	MIP vs AIP	0.040
	AIP	92.0	74.2	FB vs AIP	0.941
Abs. V35	FB	66.4	55.2	FB vs MIP	0.181
	MIP	64.9	54.5	MIP vs AIP	0.114
	AIP	66.3	55.9	FB vs AIP	0.829
Abs. V40	FB	46.0	40.4	FB vs MIP	0.522
	MIP	45.5	40.2	MIP vs AIP	0.601
	AIP	45.8	40.9	FB vs AIP	0.589

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Tian, Y., Wang, Z., Ge, H., Zhang, T., Cai, J., Kelsey, C., … Yin, F.-F. (2012). Dosimetric comparison of treatment plans based on free breathing, maximum, and average intensity projection CTs for lung cancer SBRT. *Medical Physics*, *39*(5), 2754. http://doi.org/10.1118/1.4705353

5.2.4Definition of Target Volumes and Margins

Note: All structures must be named for digital RT data submission as listed in the table below. The structures marked as "Required" in the table must be contoured and submitted with the treatment plan. Structures marked as "Required when applicable" must be contoured and submitted when applicable. Resubmission of data may be required if labeling of structures does not conform to the standard DICOM name listed. Capital letters, spacing and use of underscores must be applied exactly as indicated.

Entries in the first column of the list below will be entered and edited by the QA Staff. The PIs are required to specify the information in the second, third columns. The detailed specifications have to include crucial items such as boundary definitions and margins.

Table 5.2.4A Description and Naming of Required Target Volumes

Standard Name	Description	Validation Required/Required when applicable/Optional
GTV_XXXX	GTV to receive XXXX cGy	**Required when applicable**
IGTV_XXXX	Volume enveloping GTV motion over the course of a respiratory cycle	**Required when applicable**
PTV_XXXX	PTV to receive XXXX cGy	**Required**
PTV_2cm	Volume defined to control intermediate dose spillage	**Required**

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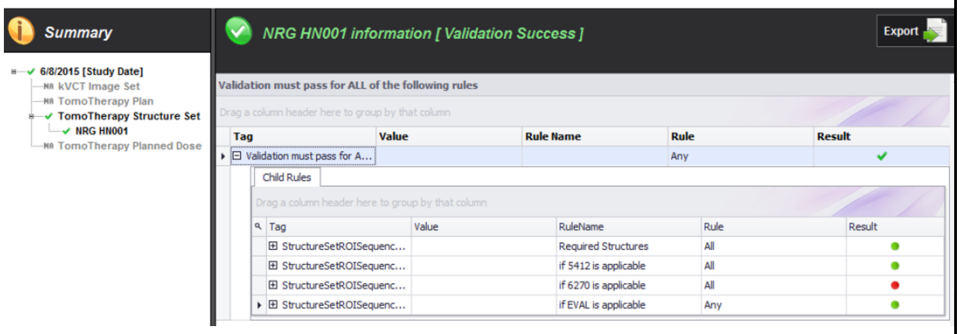
5.2.5Definition of Critical Structures and Margins



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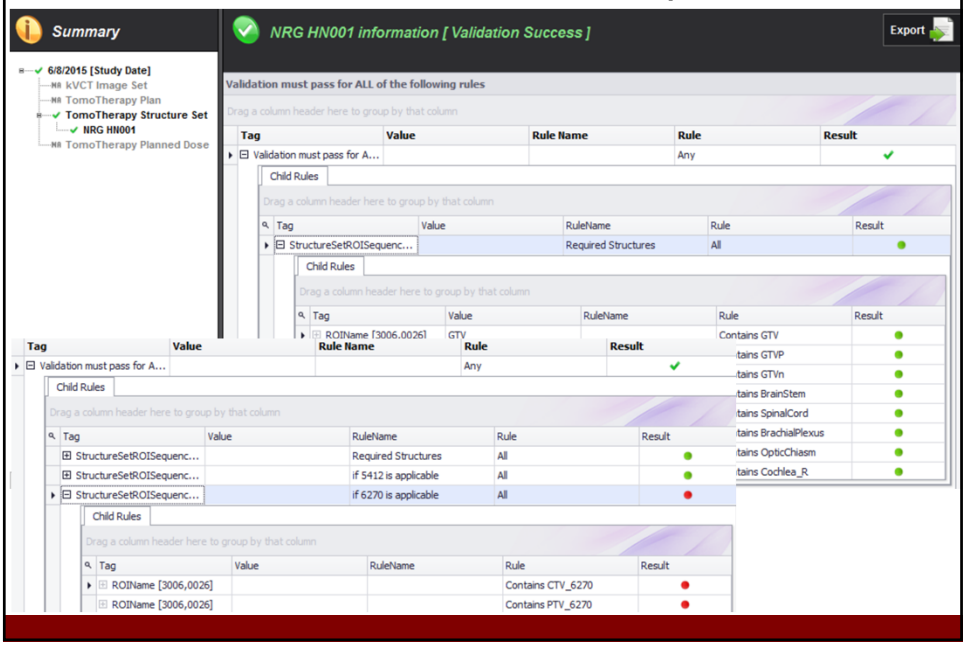
TRIAD Validation Examples



5.2.6Treatment Planning Guidelines

Topic/Parameter	Guidelines
Planning Technique	3DCRT, conformal arc, and intensity-modulated techniques (IMRT, VMAT) allowed. Tomographic and robotic techniques also allowed.
Number of Beams	As planning dictates although ≥7 beams are recommended for static beam plans due to skin toxicity considerations. Similarly, arcs should cover an appropriate range so as to deliver a safe dose to the skin.
Beam Arrangement	Coplanar or non-planar, non-overlapping, non-opposing beams or arc therapy (non-coplanar arcs allowed). Combination of static and arc beams allowed.
Beam Energy	As planning dictates although lower energies preferred for lung
Block Margin (for 3DCRT)	0-2 mm
Minimum Field Size	As planning dictates although only the smallest field size accurately commissioned (e.g. small field output factors are within 5% of published standards or values) at the institution should be used. Because of concerns with small field dosimetry, field sizes above 2 cm x 2 cm are preferable.
Dataset for Dose Calculation	ITV Approach – Average from 4DCT or normal exhale if 4DCT not available (Free breathing CT is not appropriate) Breath Hold – CT taken at treatment breath hold Gated – Average from gating window phases from 4DCT or the median phase in the gating window Tracking – 4DCT or breath hold CT Contrast Scans are not recommended for dose calculations. Recommend obtaining a non-contrast scan during simulation for dose calculation. If a contrast scan is used for dose calculation, density/material overrides are recommended when dose calculation accuracy may be affected.
Dose Calculation Algorithm	Modern algorithms that accurately handle tissue heterogeneity and scatter should be used. IROC maintains an updated list of approved algorithms. Density corrections must be applied. Density overrides of the ITV are not recommended for photon treatment. All doses should be reported in terms of dose-to-water and not in terms of dose-to-medium.
Dose Grid Resolution	2 mm x 2 mm dose grid resolution or smaller is strongly recommended.

Planning Margin

Table 2. Lung tumor MDPD, PITV, and cm^3 of non-PTV lung tissue contained in the 100, 90, 80, 50, and 25% isodose volumes for different block margins

	Blocks							MLC						
Margin (mm)	MDPD	PITV	100%	90%	80%	50%	25%	MDPD	PITV	100%	90%	80%	50%	25%
10	1.3	2.2	27	58	86	205	525	1.3	2.2	28	6	91	214	547
5	1.4	1.6	14	32	49	140	424	1.4	1.7	16	34	53	144	436
2.5	1.5	1.6	13	25	40	123	400	1.5	1.6	13	25	39	125	415
0.0	1.6	1.4	9	18	29	105	387	1.6	1.4	10	19	31	105	391
−2.5	1.9	1.4	10	18	31	113	444	1.9	1.5	11	19	32	114	445

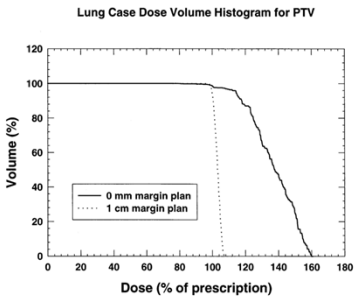


Fig. 2. DVH of the lung case PTV for treatment plans with 0 and 10-mm block margins.

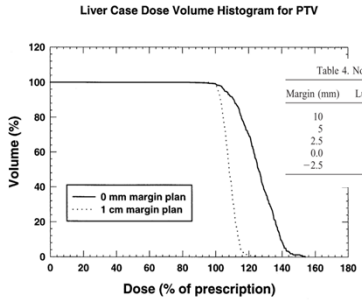


Table 4. Normal tissue complication probabilities

Margin (mm)	Lung case NTCP (%)	Liver case NTCP (%)
10	46	62
5	13	15
2.5	9	5
0.0	5	5
−2.5	6	10

Fig. 4. DVH of the liver case PTV for treatment plans with 0 and 10-mm block margins.

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Cardinale, R. M., Wu, Q., Benedict, S. H., Kavanagh, B. D., Bump, E., & Mohan, R. (1999). Determining the optimal block margin on the planning target volume for extracranial stereotactic radiotherapy. International Journal of Radiation Oncology Biology Physics, 45(2), 515–520. http://doi.org/10.1016/S0360-3016(99)00203-5

Dose Calculation Algorithm

Table 1. PTV D95 and MLD for EPL-3D, AAA, CCC, and MC algorithms in three field size groups relative to the EPL-1D (100%) method.

FS (cm)	*N*	PTV D95 (%)				MLD (%)			
		EPL-3D	AAA	CCC	MC	EPL-3D	AAA	CCC	MC
3≤FS<5	50	95.3±1.9	82.4±5.1	82.6±6.2	82.3±6.0	94.4±7.4	90.7±5.6	91.8±6.1	90.9±5.7
5≤FS<7	62	95.8±2.1	85.3±5.2	85.7±6.1	85.6±5.8	100.5±2.5	95.3±2.7	96.1±2.4	96.1±1.8
7≤FS<10	21	95.9±1.7	90.4±3.7	90.6±3.8	90.8±3.8	102.0±2.8	96.1±2.1	95.0±2.4	97.3±3.2

Table 2. PTV D95 and MLD for EPL-3D, AAA, CCC, and MC algorithms for lung-island, lung-wall and lung-central tumors relative to the EPL-1D (100%) method.

Location	*N*	PTV D95 (%)				MLD (%)			
		EPL-3D	AAA	CCC	MC	EPL-3D	AAA	CCC	MC
Lung-island	39	95.2±2.0	81.6±4.4	81.4±5.8	81.4±5.8	97.2±6.1	92.1±5.1	92.9±5.6	92.9±5.3
Lung-wall	44	96.5±1.8	86.8±4.9	87.4±5.6	86.9±5.7	98.6±6.7	94.3±4.8	94.4±4.3	94.9±4.9
Lung-central	50	95.2±1.8	86.2±5.9	86.5±6.3	86.7±6.0	99.3±4.8	94.5±3.7	95.4±3.8	95.0±3.8

Devpura, S., Siddiqui, M. S., Chen, D., Liu, D., Li, H., Kumar, S., … Chetty, I. J. (2014). Recommendations for dose calculations of lung cancer treatment plans treated with stereotactic ablative body radiotherapy (SABR). *Journal of Physics: Conference Series*, *489*, 012007. http://doi.org/10.1088/1742-6596/489/1/012007

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5.2.7Compliance criteria

Table 5.2.7A Target Volume Constraints and Compliance Criteria (THESE ARE JUST EXAMPLES and should be determined by the protocol PIs – effort should be made to be consistent with existing protocol when possible**)**

Name of Structure	Dosimetric parameter*	Priority	Per Protocol	Variation Acceptable	Notes (if needed)
PTV_XXXX	$D_{95\%}$(Gy)				
	$D_{99\%}$(Gy)				
	$D_{1\%}$(Gy)				

Table 5.2.7B Normal Structure Constraints and Compliance Criteria (THESE ARE JUST EXAMPLES and should be determined by the protocol PIs – effort should be made to be consistent with existing protocol when possible**)**

Name of Structure	Dosimetric parameter	Priority	Per Protocol	Variation Acceptable	Endpoint/Notes
Lungs	V_{5Gy}(%)				
	V_{20Gy}(%)				
	D_{mean}(Gy)				

Table 5.2.7C Additional Target and Normal Structure Recommendations – Not to be used in plan scoring or acceptability (THESE ARE JUST EXAMPLES and should be determined by the protocol PIs – effort should be made to be consistent with existing protocol when possible**)**

Name of Structure	Dosimetric parameter	Recommendation	Notes
OAR1	D_{mean}(Gy)	≤ 30 G	
nonPTV	D_{1cc} (Gy)	≤ 105%	

Table 5.2.7D Delivery Compliance Criteria

Delivery Metric	Per Protocol	Variation Acceptable	Notes
Start date (X days/weeks after X) (Please remove this row when the start date is not specified in the protocol.)			
Overall Treatment time			
Interruptions			

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5.2.8 Treatment Planning Priorities and Instructions

Table 5.2.8A Treatment Planning Priorities

Planning Priority	Instructions
1	Respect all Priority 1 OAR criteria in Table 5.2.7A to at least Variation Acceptable levels
2	Achieve Priority 2 PTV coverage criteria in Table 5.2.7B while minimizing conformity and gradient indices (i.e. achieve conformity and compactness of the dose distribution). In cases of overlap with Priority 3 OAR criteria, it is recommended to allow variation acceptable levels of target coverage and minimize hotspots in OAR overlap areas. Intensity modulated techniques may be desirable.
3	Meet Priority 3 OAR criteria in Table 5.2.7A
4	Meet recommended criteria in Table 5.2.7C

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5.2.9 Patient specific QA

Any patient-specific QA that needs to be acquired should follow institutional guidelines. For intensity modulated techniques, patient specific QA is highly recommended.

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5.2.10Daily Treatment Localization/IGRT

Treatment Technique	Acceptable Methods for Daily Image Guidance	Matching Instructions
ITV/free breathing (includes abdominal compression)	Volumetric Imaging Volumetric Imaging (i.e. CBCT or CT on rails) is strongly recommended	• Initial rigid alignment followed by soft tissue match with average CT and slow CBCT • 4DCT to 4D-CBCT can be used when capability exists
	Planar Imaging If volumetric imaging is not available, then an appropriate tumor surrogate (i.e. implanted fiducials) must be able to be accurately imaged in the treatment position with 2D imaging. The patient surface is not an appropriate surrogate for tumor setup although surface based imaging may be used during treatment to assess unexpected patient motion. Note that when orthogonal 2D imaging (with or without implanted fiducials) is employed for sites where respiratory motion is expected and not controlled via motion management techniques, care must be taken to ensure accurate targeting of the ITV within the treatment. For example, static kV imaging at an undetermined breath hold position would not be adequate IGRT for treating a free-breathing lung tumor. Repeat imaging during treatment is recommended to verify that the tumor is in the ITV If any significant baseline shifts are noted, resimulation should be strongly considered	• Rigid alignment to bony anatomy • Repeat imaging to ensure tumor surrogate is within ITV • Repeat imaging at each treatment port to ensure tumor surrogate remains within the ITV is very strongly recommended
Gating with a gating window	The baseline gating position/phase should be verified using appropriate imaging techniques Volumetric Imaging (i.e. CBCT or CT on rails) is strongly recommended for the initial localization to verify isocenter and tumor trajectory	• Initial rigid alignment followed by soft tissue match for baseline gating position
Gating with breath hold (ie ABC)	Volumetric imaging recommended; planar at breath hold position acceptable – repeated imaging recommended to ensure reproducibility of breath hold All imaging should be done at breath hold treatment position	• Initial rigid alignment followed by soft tissue match of tumor or surrogate
Tracking	Volumetric imaging or real-time fluoroscopic imaging of tumor surrogate required based on treatment machine capabilities.	• Initial rigid alignment followed by soft tissue match of tumor or surrogate in baseline position

IGRT Investigations

Table 4. Mean, systematic, and random residual setup error for five imaging protocols

	ML (mm)			CC (mm)			AP (mm)		
Imaging protocol	M	Σ	σ	M	Σ	σ	M	Σ	σ
No IG	−0.20	1.5	2.9	0.10	2.2	3.7	0.34	1.6	2.5
First 5-day IG	−0.21	2.0	2.9	1.29	2.6	3.7	0.16	1.8	2.5
Weekly IG	−0.20	1.3	2.7	0.07	1.7	3.5	0.24	1.4	2.4
Alternate IG	−0.23	1.0	2.4	0.09	1.3	3.1	0.23	1.2	2.1
Daily IG	−0.29	0.9	1.7	0.03	0.7	2.0	0.09	1.0	1.7

Abbreviations: ML = mediolateral; CC = craniocaudal; AP = anteroposterior; M = mean; Σ = systematic error; σ = random residual setup error; IG = image-guidance.

Higgins, J., Bezjak, A., Hope, A., Panzarella, T., Li, W., Cho, J. B. C., … Bissonnette, J. P. (2011). Effect of image-guidance frequency on geometric accuracy and setup margins in radiotherapy for locally advanced lung cancer. *International Journal of Radiation Oncology Biology Physics*, *80*(5), 1330–1337. http://doi.org/10.1016/j.ijrobp.2010.04.006

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Summary

- CIRO – the Resource for Implementation of Advanced Radiation Therapy in Clinical Trials
- SBRT Guidelines from Radiation Oncology Community Studies
- NRG Protocol Radiation Therapy Sections Follows Clinical Processes
- We appreciate feed back to improve

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THANK YOU!

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