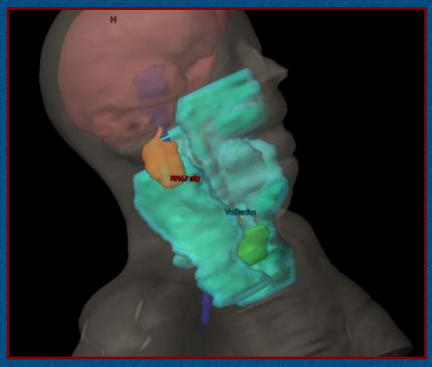
Head and Neck Treatment Planning



Charles Mayo, Ph.D.

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Disclosure

- Grants from Varian Medical System

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Thanks for contributions to this talk from

Robert Foote, M.D.
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Brett Kazemba, CMD, RTT
Janelle Miller, CMD,RTT
Alan Kraling, CMD, RTT
Pam Lemish, CMD
Kathy Hoeft, CMD, RTT
Nissa Kraling, CMD
Kevin Kisrow, CMD, RTT
Stephanie Wurgler, CMD, RTT

From M.D. Anderson
Lei Dong, Ph.D.
Stephen Kry, Ph.D.

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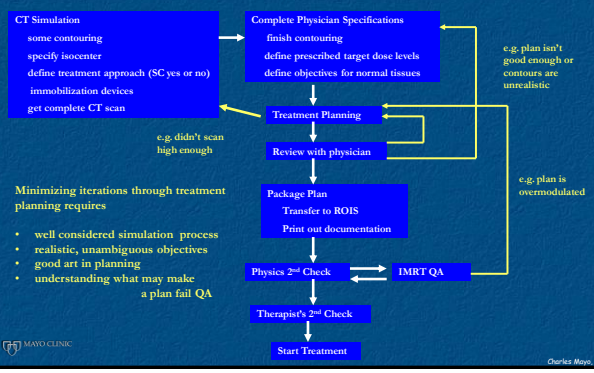
Elements of a Process Flow

Trying use good planning to eliminate iterations



Minimizing iterations through treatment planning requires

- well considered simulation process
- realistic, unambiguous objectives
- good art in planning
- understanding what may make a plan fail QA

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CT simulation

- Scan high enough (sometimes non-coplanar beam arrangement will be found to be useful, but this can only be done if the CT scan encompasses the whole head)
- Immobilization consistent with objectives
  - Tempting to think you don't need good reproducibility for a GBM, but if there are tight constraints on an abutting structure, e.g. optic chiasm this is realistic only if the immobilization is commensurate

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Complete Physician Specification

- Dependent on clinic this can range from
  - "Cover the CTV and do as well as you can on the rest"
  - To Detailed list of structures and DVH objectives
  - Physicians, Dosimetrists and Physicists need to be able to plan in their heads, to be realistic about what is achievable and where the issues will be.

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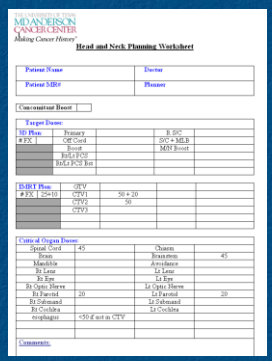
Communicating Physician Objectives

a range of approaches and specificity



MD ANDERSON CANCER CENTER
Making Cancer History®

Head and Neck Planning Worksheet

Patient Name	Doctor
Patient MR#	Planner

Concomitant Boost

Target Doses:

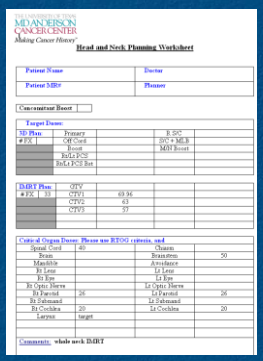
3D Plan	Primary		R SPC
# FX	Off Cord		SVC + MLB
	Boost		MH Boost
	BoLz PCF		
	BoLz PCF Bst		

IMRT Plan	CTV			
# FX 25+10	CTV1	50 + 20		
	CTV2	50		
	CTV3			

Critical Organ Doses:

Spinal Cord	45	Chiasm	
Brain		Brainstem	45
Mandible		Arytenoid	
Rt Lens		Lt Lens	
Rt Eye		Lt Eyes	
Rt Optic Nerve		Lt Optic Nerve	
Rt Parotid	20	Lt Parotid	20
Rt Submand		Lt Submand	
Rt Cochlea		Lt Cochlea	
esophagus	<50 if not in CTV		

Comments:



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Target Doses:

3D Plan	Primary		R SPC
# FX	Off Cord		SVC + MLB
	Boost		MH Boost
	BoLz PCF		
	BoLz PCF Bst		

IMRT Plan	CTV			
# FX 33	CTV1	69.96		
	CTV2	63		
	CTV3	57		

Critical Organ Doses: Please use RTOG criteria, and

Spinal Cord	40	Chiasm	
Brain		Brainstem	50
Mandible		Arytenoid	
Rt Lens		Lt Lens	
Rt Eye		Lt Eyes	
Rt Optic Nerve		Lt Optic Nerve	
Rt Parotid	26	Lt Parotid	26
Rt Submand		Lt Submand	
Rt Cochlea	20	Lt Cochlea	20
Larynx	target		

Comments: whole neck IMRT

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Stephen Kry, Ph.D.

Communicating Physician Objectives

a range of approaches and specificity

Our current template typically specifies 50-75 normal tissue objectives, and 11-27 target (ctv-ptv) tissue objectives

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QUANTEC Normal Tissue Outcome Summaries and Typical Plan Objectives

- Parotid
  - Mean < 25 Gy Total (<20% reduction in function < 25%)
  - Mean < 20 Gy Contralateral (<20% reduction in function < 25%)
  - Mean < 39 Gy Total (<50% reduction in function < 25%)
- Spinal Cord
  - Dmax < 50 Gy (<0.2 % Myelophathy)
  - Dmax < 60 Gy (< 6% Myelophathy)
- Pharyngeal Constrictors
  - Mean < 50 Gy (< 20% Symptomatic dysphagia and aspriation)
- Larynx
  - Dmax < 66 Gy (< 20% Vocal dysfunction)
  - Mean < 50 Gy (< 30% Aspiration)
  - Mean < 44 Gy (< 20% Edema)
  - V50 < 27% (< 20% Edema)
- Esophagus
  - Mean < 34 Gy (5-20% Acute Esophagitis, Grade ≥ 3)
  - V35 < 50% (<30% Acute Esophagitis, Grade ≥ 2)
  - V50 < 40% (<30% Acute Esophagitis, Grade ≥ 2)
  - V70 < 20% (<30% Acute Esophagitis, Grade ≥ 2)

- Parotid Contralateral
  - Mean < 26 Gy
  - V30 < 50%
  - V40 < 33%
- Parotid Total
  - Mean < 39 Gy
- Spinal Cord
  - Dmax < 45 Gy
- Pharyngeal Constrictors
  - Dmax < 50 Gy
  - V55 < 80%
  - V65 < 30%
- Larynx
  - Dmax < 66 Gy
  - Mean < 35 Gy
  - V50 < 27%
- Esophagus
  - Mean < 34 Gy
  - V35 < 50%
  - V50 < 40%
  - V70 < 20 %

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Standardized Approach to IMRT/VMAT optimization

- Contouring and beam selection "recipe" using dose sculpting structures that works to meet most objectives. Images are on Eclipse system, but general approach should work on any system.
- Fine tune dose sculpting structures and constraints as needed
- Cook book
  - Standard Structures
    - CTVs, PTVs,
    - Brain, Skin
    - IMRT PTVs, DLAs, DL40, Buffer, Airway Buffer
  - 3 Arc beam selection or 7-9 field IMRT
  - First Pass on optimization
    - IMRT PTVs
    - DLAs and *Normal Tissue Objective* ← *Non-critical vendor specific item*
    - Control gradient to cord/brain stem with DL40
    - Push low dose end of parotids
    - Push median region on larynx

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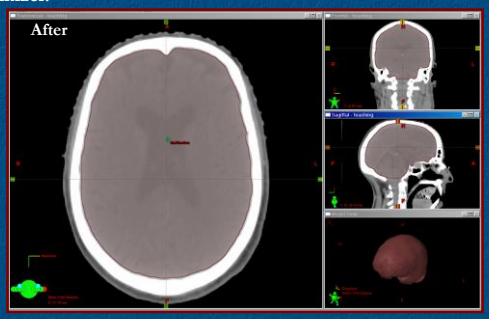
Brain

- When target volumes are extend quite far superiorly, it is easy for there to spillage of intermediate dose into the cranium
- Contour the brain, so that you can keep an eye on this in the optimizer.



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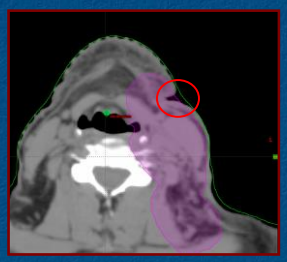
Skin

- Check that when auto contouring of skin was done, it didn't cross air gaps in high radius of curvature regions
- This is a problem when PTV or IMRT PTV is trimmed back from skin by 3 mm.



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Skin Dose

- Due to multiple tangential beams
- Bolus effect of mask (Xia et al. - 18% increase - cut out mask over anterior neck)
- Risk increased dose if contour close to skin
  - contour skin as sensitive structure (constraint to 55 Gy) decrease skin dose ~ 20 %

Lee et al., IJROBP *53 (3):630-637, 2002.*

Lei Dong 2/29/2008

CTV, PTV, IMRT PTV

- CTV is a physical structure that reflects "where the dose needs to go" to cover gross and microscopic disease
- PTV is a statistical structure that reflects a 95%CI envelope of where the CTV might be located day to day due to error bars on patient setup and motion.
- Keeping ICRU definitions of CTV, PTV facilitates inter and intra institutional comparisons of outcomes
- Copy PTV into another structure, IMRT PTV, to use for optimization and reflecting dose compromises that the physician might want to make.

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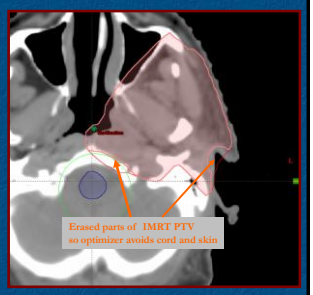
CTV, PTV, IMRT PTV

- Copy PTV into another structure, IMRT PTV, to use for optimization and reflecting dose compromises that the physician might want to make.
  - e.g. erase portion of IMRT PTV that abuts cord or parotid if the physician wants to compromise on PTV coverage to reduce dose to these structures. This way DVH honestly reflects compromise on PTV to spare normal tissue.
  - Use PTV to analyze DVH
    Use IMRT PTV to guide optimizer
  - IMRT to guide the optimizer on how to shape the dose to meet the physicians objectives



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CTV, PTV, IMRT PTV

- Multiple dose level PTVs in the prescription => Multiple dose level IMRT PTVs
- Crop the high dose IMRT PTVs out of the low dose IMRT PTVs with a 1 mm margin

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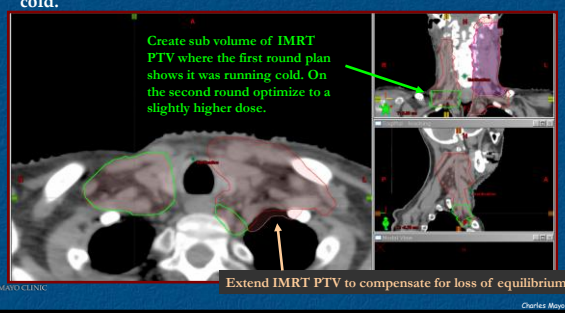
CTV, PTV, IMRT PTV

- Another approach, is to identify a sub-volume of the IMRT PTV that needs special focus in planning. After first round of planning, create a structure from the prescribed isodose line. Then boolean with IMRT PTV and manual edits to identify region that is running cold.



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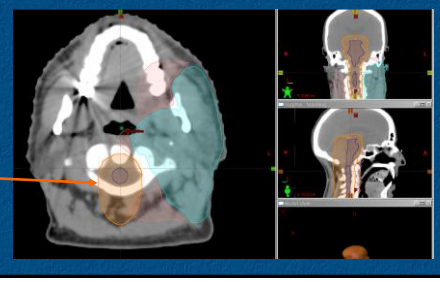
DL40

- Buffer on spinal cord and brain stem. Use it to control dose gradient by driving ~40Gy volume down.
- Create as boolean on spinal cord and brain stem. Add 1 cm margin in all directions except posterior where 3 cm is used
- Keep spinal cord and brain stem PRVs, for dose evaluation



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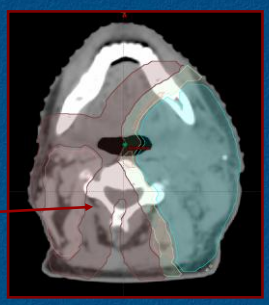
DLA

- Ring around each of the IMRT PTVs, used to help keep prescribed isodose lines conformal to PTVs
- High Dose DLA: 1 cm margin, crop high dose IMRT PTV with 0.1 cm margin
- Low Dose DLA: 2 cm margin, crop low dose IMRT PTV with 0.1 cm margin. Crop out of high dose IMRT PTV with 1 cm margin



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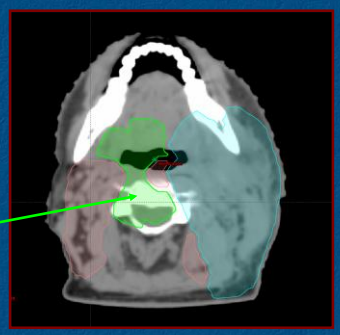
Buffer

- Optimizer tends to view regions between target volumes as a good place to put hot spots.
- Create a buffer structure with roughly paint brushing area between and then cropping with margin to remove parts overlapping the IMRT PTVs



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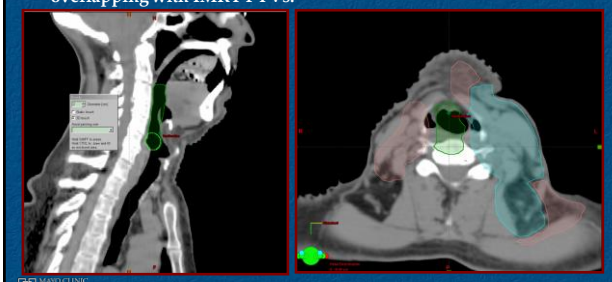
Airway Buffer

- Many of the normal tissues to spare lie along the airway
- Contour airway in saggital plane using 3D brush, margin with 1 cm lateral and posterior, crop with 0.5 cm margin to keep only part not overlapping with IMRT PTVs.



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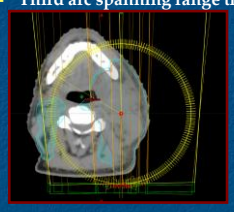
Beam Selection

- The default is to place iso-center in the high dose CTV.
- IMRT
  - 7-9 Symmetrically spaced beams
  - Rotate collimator to minimize number of carriage splits
- VMAT
  - 179-181 CCW, Collimator 30°
  - 181 – 179 CW, Collimator 330°
  - Third arc spanning range that targets high dose CTV, 30 ° or 330 °



All together

Just the 3rd arc

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Optimize

- Max and Min on IMRT PTVs
- Max on DLAs corresponding to IMRT PTV min doses. Push on mid range to force gradient.
- Set max dose to cord ~35 – 40 Gy as needed. Push down volume at matching dose in DL40 to drive dose gradient near to cord/brain stem
- Push low dose end of parotids
- Push high/intermediate dose out of brain
- Push high dose out of buffer
- Push intermediate dose levels in airway buffer
- Push low and intermediate dose level on larynx,esophagus, constrictors as needed.

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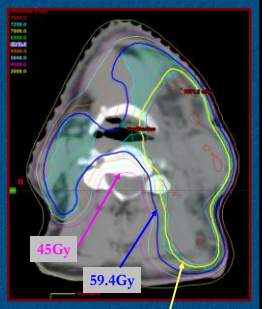
Dose Distribution

- The approach will provide a good overall dose distribution. Fine tuning on a per patient basis may be needed in subsequent round.
- Keep expectations reasonable
  - Highest achievable dose gradients near spinal cord, larynx, ect will be in the range of 35-45 %/cm, dependent upon separation between high dose targets.
  - Away from targets and high gradient regions, fall off will be on the order of 15-25 %/cm



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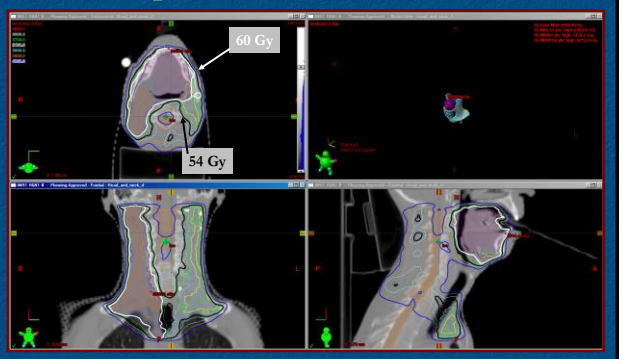
Examples of Dose Distributions



IMRT 9 field (18 with carriage splits)

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Examples of Dose Distributions

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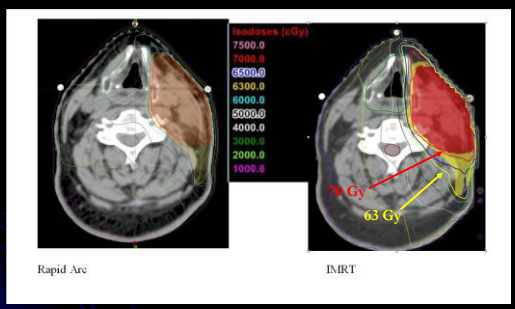
Examples of Dose Distributions



MD Anderson Example

Stephen Kry, Ph.D.

Approach to treating the supra clavicular region

- Typically either
  - IMRT matched to static AP SC field with/without cord block
  - IMRT fields that treat SC as well as upper head/neck

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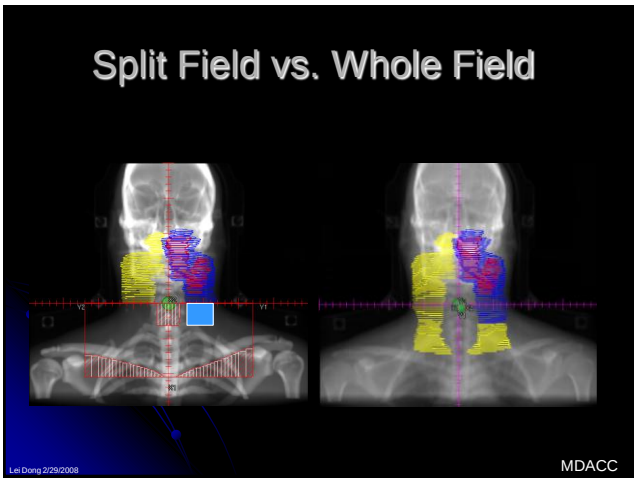
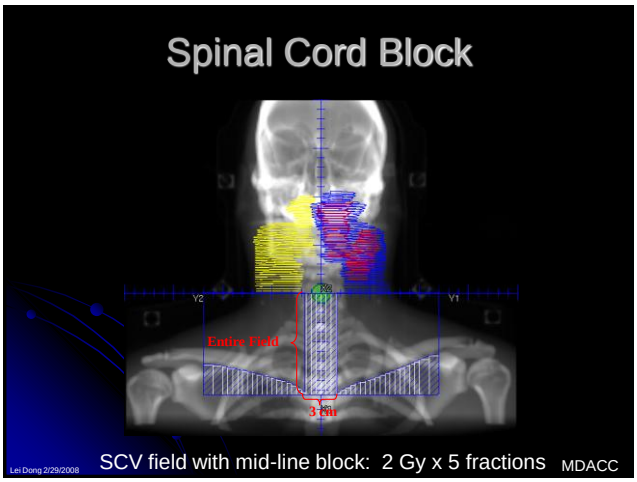
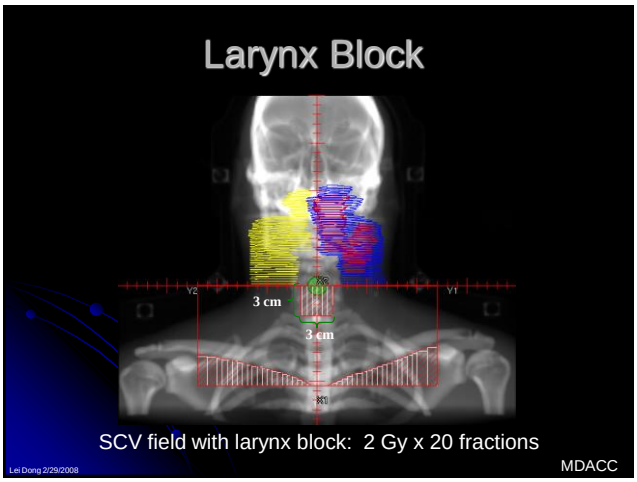
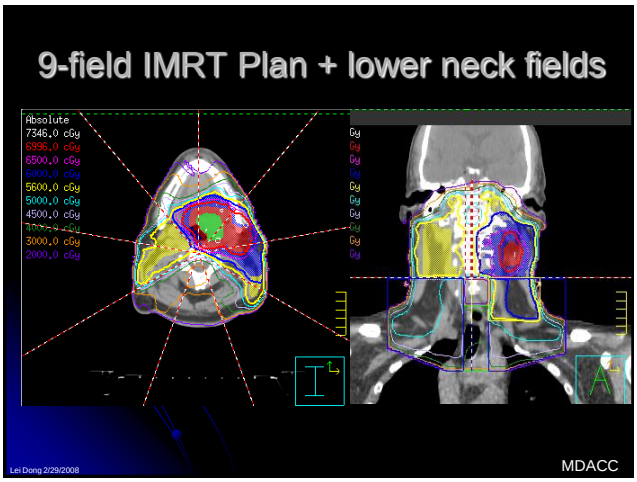

Split Field vs. Whole Field
Lei Dong 2/29/2008
MDACC


Spinal Cord Block
Entire Field
3 cm
Lei Dong 2/29/2008
SCV field with mid-line block: 2 Gy x 5 fractions
MDACC


Larynx Block
3 cm
3 cm
SCV field with larynx block: 2 Gy x 20 fractions
Lei Dong 2/29/2008
MDACC


9-field IMRT Plan + lower neck fields
Absolute
7346.0 cGy
6936.0 cGy
6500.0 cGy
6000.0 cGy
5600.0 cGy
5000.0 cGy
4500.0 cGy
3000.0 cGy
2000.0 cGy
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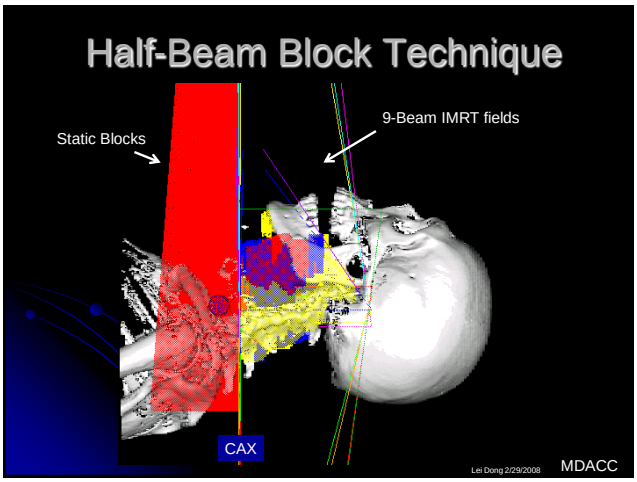

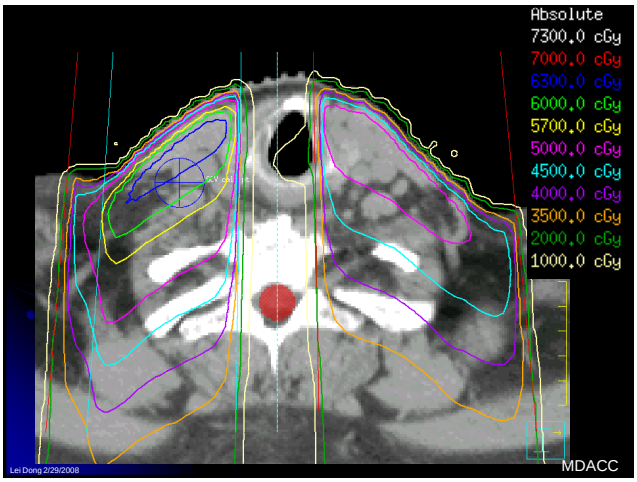

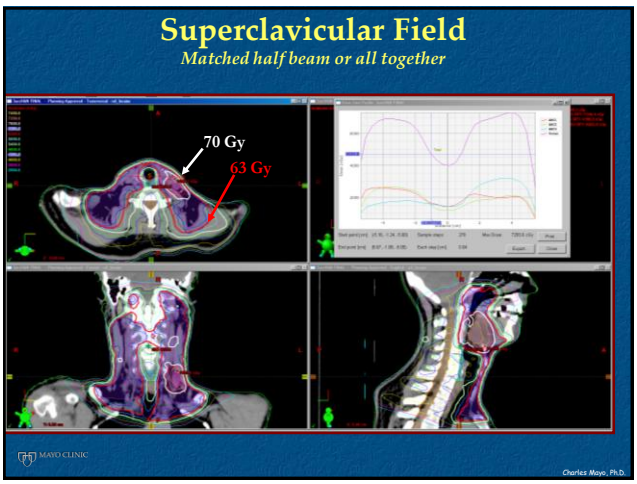

Summary

- Treatment planning is an art form based in science
- Communication on realistic expectations on the balance between target and normal tissue objectives is key to avoiding iterations through the planning cycle
  - Importance of being able to visualize an achievable dose distribution, before beginning to plan
- Both IMRT and VMAT solutions work

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