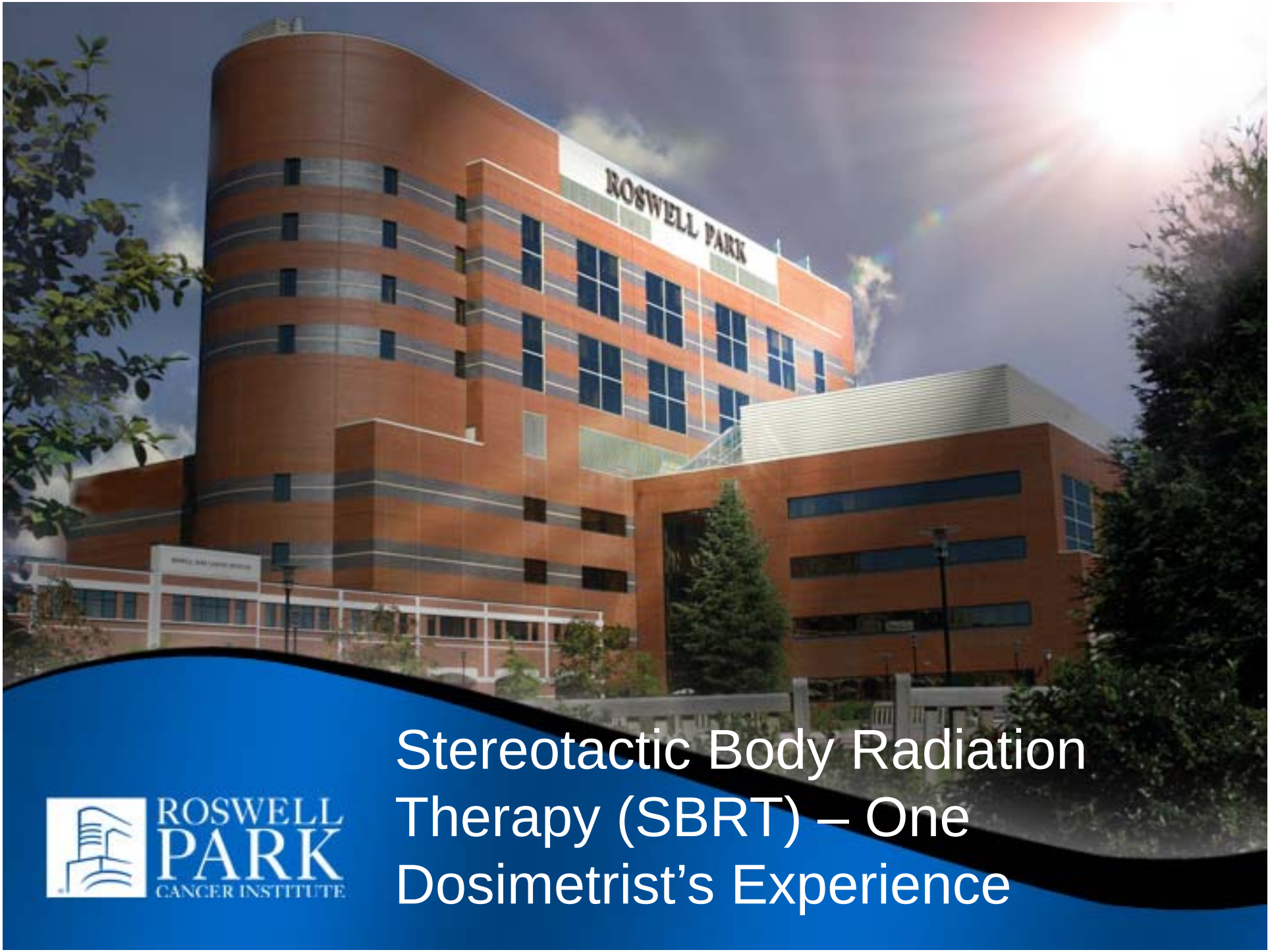

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Stereotactic Body Radiation Therapy (SBRT) – One Dosimetrist's Experience

SBRT Definition

What is SBRT?

- **S**tereotactic
- **B**ody
- **R**adiation
- **T**herapy

SBRT Definition

Stereotactic

- Stereotaxy = the superposition of a 3D co-ordinate system upon a given organ or structure.
- Requires an external frame, fixed to the body and treatment apparatus.
- The cranium is really the only site this is practical for.

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SBRT Definition

SBRT Definition

Body

- This seems like an odd descriptor of radiation therapy… isn't it all given to the body?
- Body = Extracranial

SBRT Definition

Radiation Therapy

- Hopefully, we all have some idea what this is… or do we…?

SBRT Definition

Standard Radiation Therapy

- Developed over the last 70 years
- Fractionated
- Daily Dose 1.8 – 2.0 Gy
- 2 – 4 Fields

SBRT Definition

Standard Radiation Therapy

- Functions by disrupting cellular division
- Cellular division is a complex process
- Disruption of any part of this process can lead to loss of reproductive integrity
- “Multiple high-value targets”

SBRT Definition

Standard Radiation Therapy

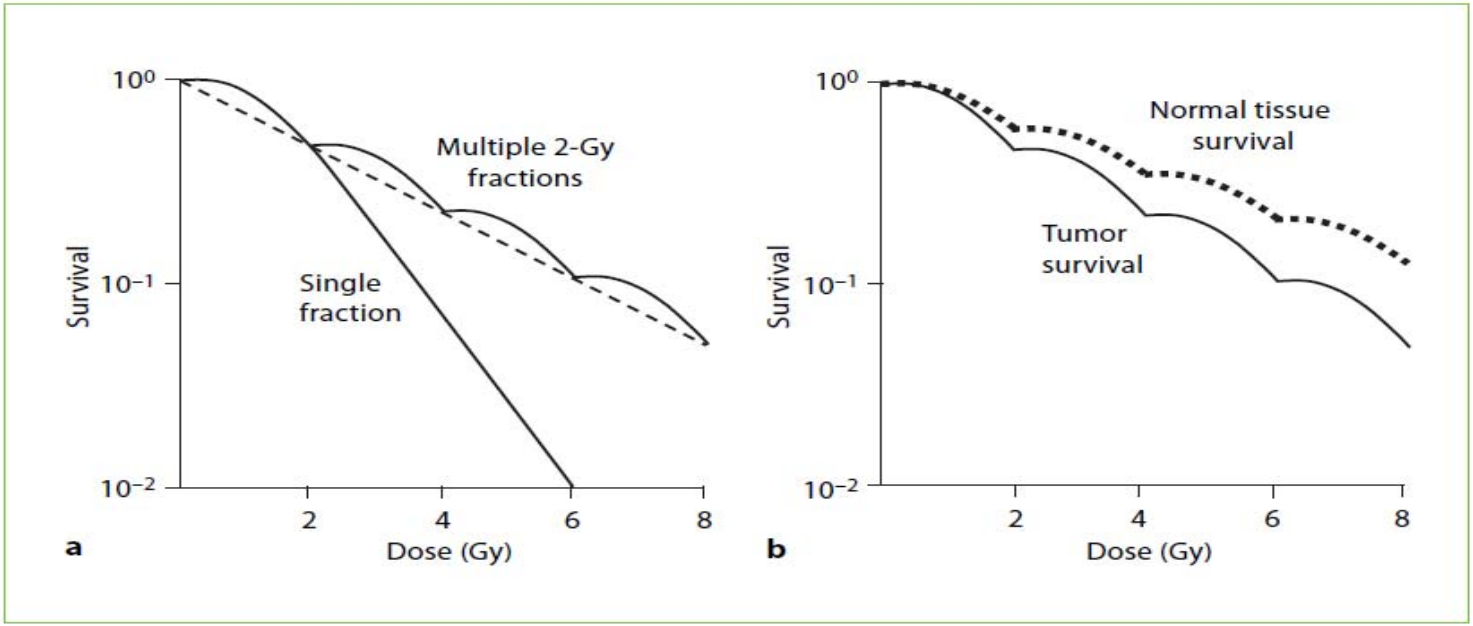


Fig. 1. a Typical cell survival curve shape comparing single-dose and multiple-dose radiation exposure. **b** Cell survival differs between normal tissues and tumor tissues for multiple-fraction exposure.

Meyer, et al. 2007

SBRT Definition

Standard Radiation Therapy

- Why fractionate?
  - Normal Tissue
  - Increasing dose / fraction using traditional techniques usually leads to increased toxicity
  - Traditional techniques included too much normal tissue

SBRT Definition

SBRT

- Delivery of high dose in few fractions
- SBRS (Stereotactic Body Radio Surgery) = 1 fraction
- SBRT = 2 – 5 fractions

SBRT Definition

SBRT

- Functions by destroying target cellular function
- Any individual cellular function is typically simpler than cellular reproduction… but all of functionality must be destroyed
- “Cumulative loss of low-value targets”

SBRT

SBRT

- We need to be able to deliver high dose / fraction without toxicity
- Changes to
  - Simulation
  - Treatment Planning
  - Treatment Delivery

SBRT Simulation

SBRT Simulation

- Immobilization
  - Body frames / bags – indexable
- High resolution CT (0.25cm or less)
- Respiratory Motion
  - Compression plates / wraps
  - Respiratory Gating – prospective or retrospective

SBRT Delivery

SBRT Treatment Delivery

- High accuracy daily target localization
- IGRT
  - CBCT
  - kV / MV imaging
  - Ultrasound

SBRT Treatment Planning

SBRT Treatment Planning

- High accuracy target definition
  - Internal Target Volume (ITV) construction considering the role of respiratory motion
- Highly conformal dose volumes
  - Multiple beams (7 – 11), IMRT, VMAT
- Sharp dose gradients
  - Small field sizes, dose prescription to low isodoses, acceptance of dose inhomogeneity inside target

RPCI SBRT Experience

- Started our SBRT Lung program in 2007
- We also treat:
  - Liver
  - Adrenal / Kidney
  - Spinal Metastases
  - Head and Neck
- As of Sept 1 2016 – 536 cases

Lung SBRT Experience

- Lung SBRT (approx. 90% of cases)
- Follow RTOG protocols
  - 0236
  - 0813
  - 0915
- Developed internal protocols and clinical trials based upon the RTOG studies

Lung SBRT Guidelines

- Target Definition
  - ITV is constructed based upon evaluation of the respiratory motion
  - Binned into 10% increments of respiratory cycle
  - Segments with too much motion are not used for ITV generation and will not be treated
  - PTV = ITV + 0.5cm

Lung SBRT Guidelines

- Dose Constraints – Target
  - High conformality, sharp dose gradients
  - Dose is typically prescribed to the highest isodose value that:
    - Covers 95% of PTV
    - Is between 60% and 90% of prescription dose
  - Why 60 – 90%?
    - Field conform to target with virtually no margin - 95% cannot cover volume
    - Field sizes must be kept as small as possible to spare normal tissue

Lung SBRT Guidelines

- Dose Constraints – Target
  - High Dose Conformality
    - 95% of PTV covered by 100% of prescription dose
    - 99% of PTV covered by 90% of prescription dose
  - High Dose Spillage
    - 100% Conformality Index
      - Ratio of prescription dose volume / PTV volume less than 1.2
    - Volume of tissue outside the PTV exceeding 105% must be less than 15% of PTV volume

Lung SBRT Guidelines

- Dose Constraints – Target
  - Low Dose Spillage
    - 50% Conformality Index
      - Ratio of 50% prescription dose volume / PTV volume
      - Value varies based upon PTV volume
      - Lower acceptable limit as PTV volume increases
      - Range 2.9 – 3.9
    - Maximum Dose 2cm from PTV
      - Value varies based upon PTV volume
      - Higher acceptable limit as PTV volume increases
      - Range 46.8 – 73.8 % rx dose

Lung SBRT Guidelines

- Dose Constraints – Organs at Risk
  - Standard dose constraints don't work due to:
    - High dose / fraction
    - Different mechanisms of cell damage
  - Data from earlier protocols that resulted in "good" plans was used to determine dose limits, which are then modified according to total prescription dose

Lung SBRT Guidelines

- Dose Constraints – Organs at Risk

Constraints	RTOG 0236 60 Gy / 3 Fx	RTOG 0813 50 – 60 Gy / 5 Fx	RTOG 0915 34 – 48 Gy / 1 – 4 Fx	RPCI I-124407 30 – 60 Gy / 1 – 3 Fx
Lung V20	10 %	10 %	10 %	10 %
Lung V12.5		1500 cc		
Lung V13.5		1000 cc		
Lung V7			1500 cc	1500 cc
Lung V7.4			1000 cc	1000 cc
Spinal Cord Max	18 Gy	30 Gy	14 / 26 Gy	14 / 18 Gy
Spinal Cord V13.5		0.5 cc		
Spinal Cord V7			1.2 cc	1.2 cc

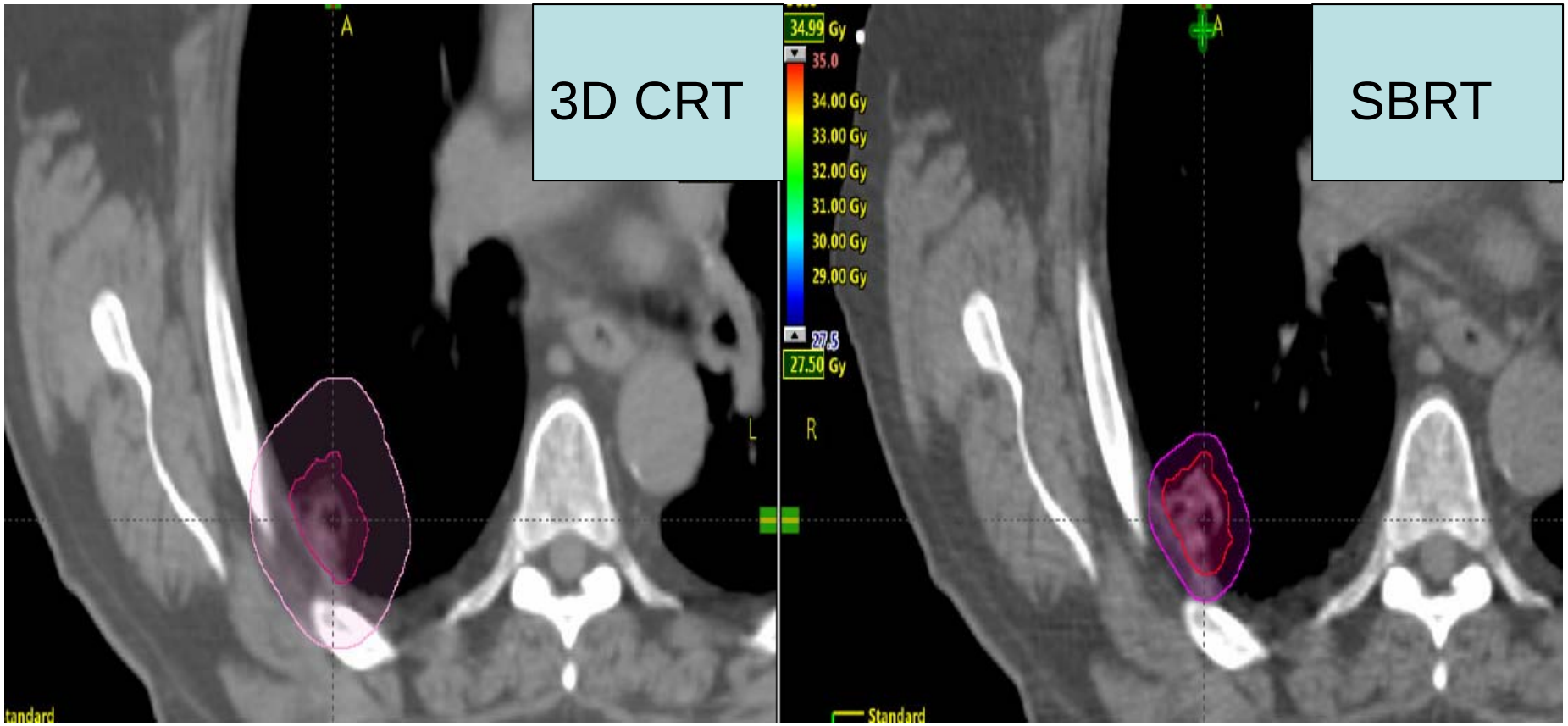
Lung SBRT vs 3DCRT

- Planning Techniques

	Standard 3DCRT	**SBRT**
Prescription	60 – 66 Gy	30 – 60 Gy
Dose / Fx	1.8 – 2.0 Gy	10 – 30 Gy
GTV / ITV Determined by	Free Breathing / Breath Hold CT	Respiratory Phase Analysis
PTV	GTV + 1.0 – 1.5cm	ITV + 0.5cm
Technique	2 – 4 Fields	7-11 Fields
Block Margin	0.8 – 1.2cm	0.0 – 0.2cm

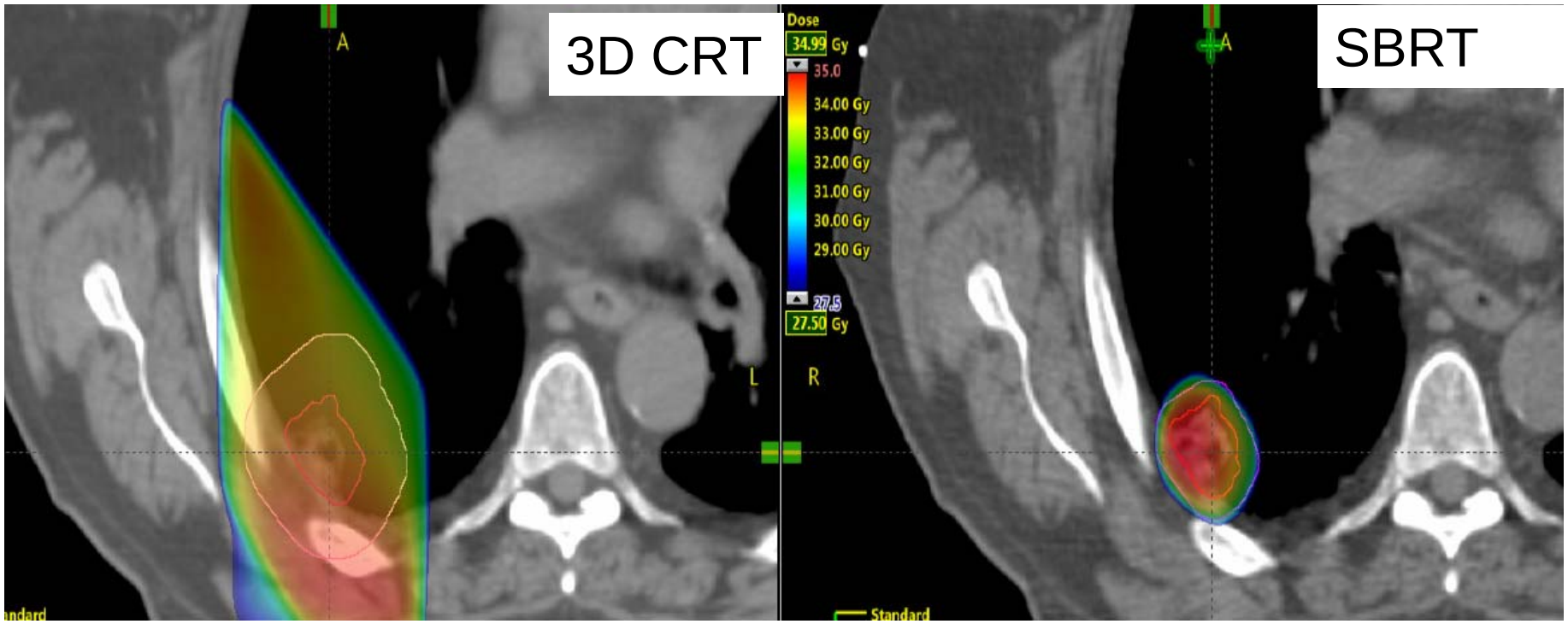
Lung SBRT vs 3DCRT

- Targets



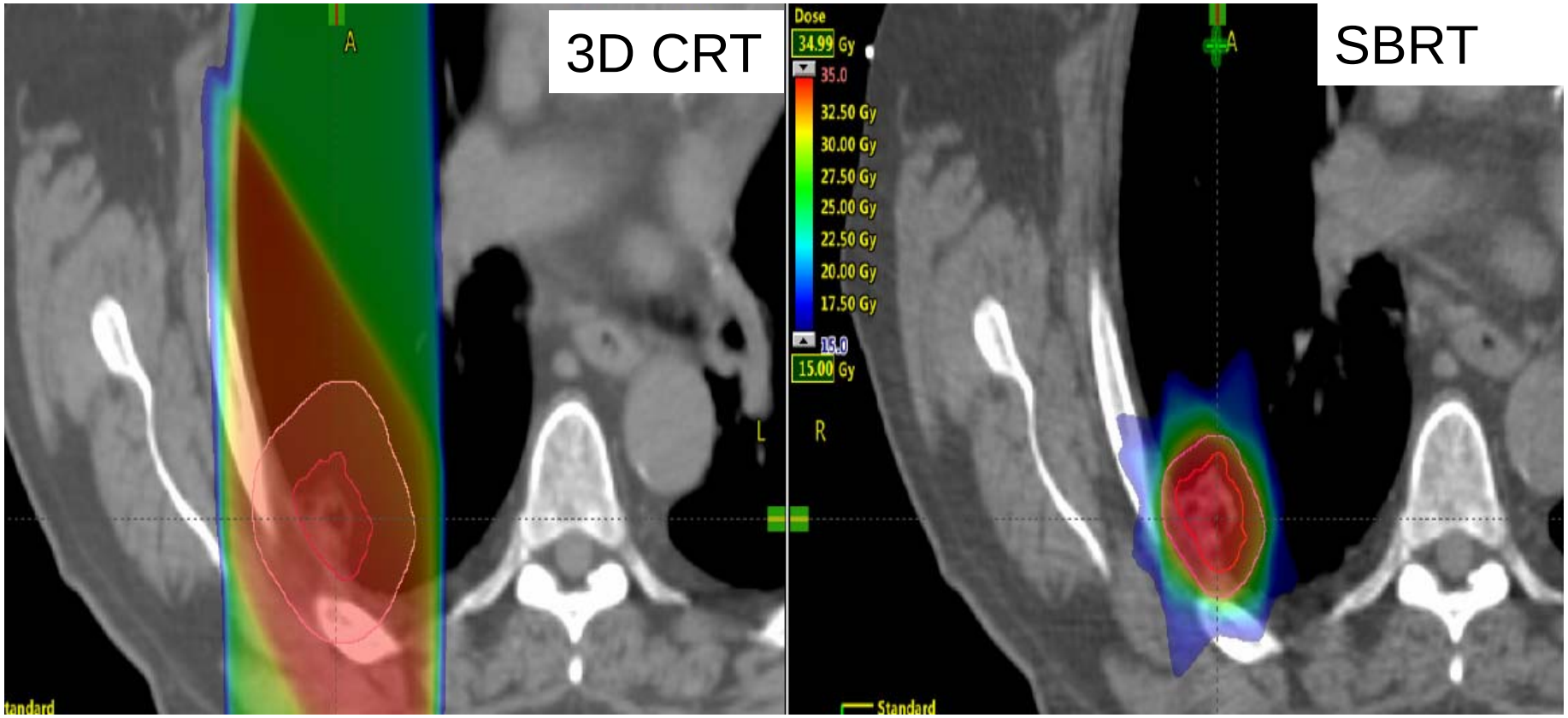
Lung SBRT vs 3DCRT

- 95% Isodose Coverage



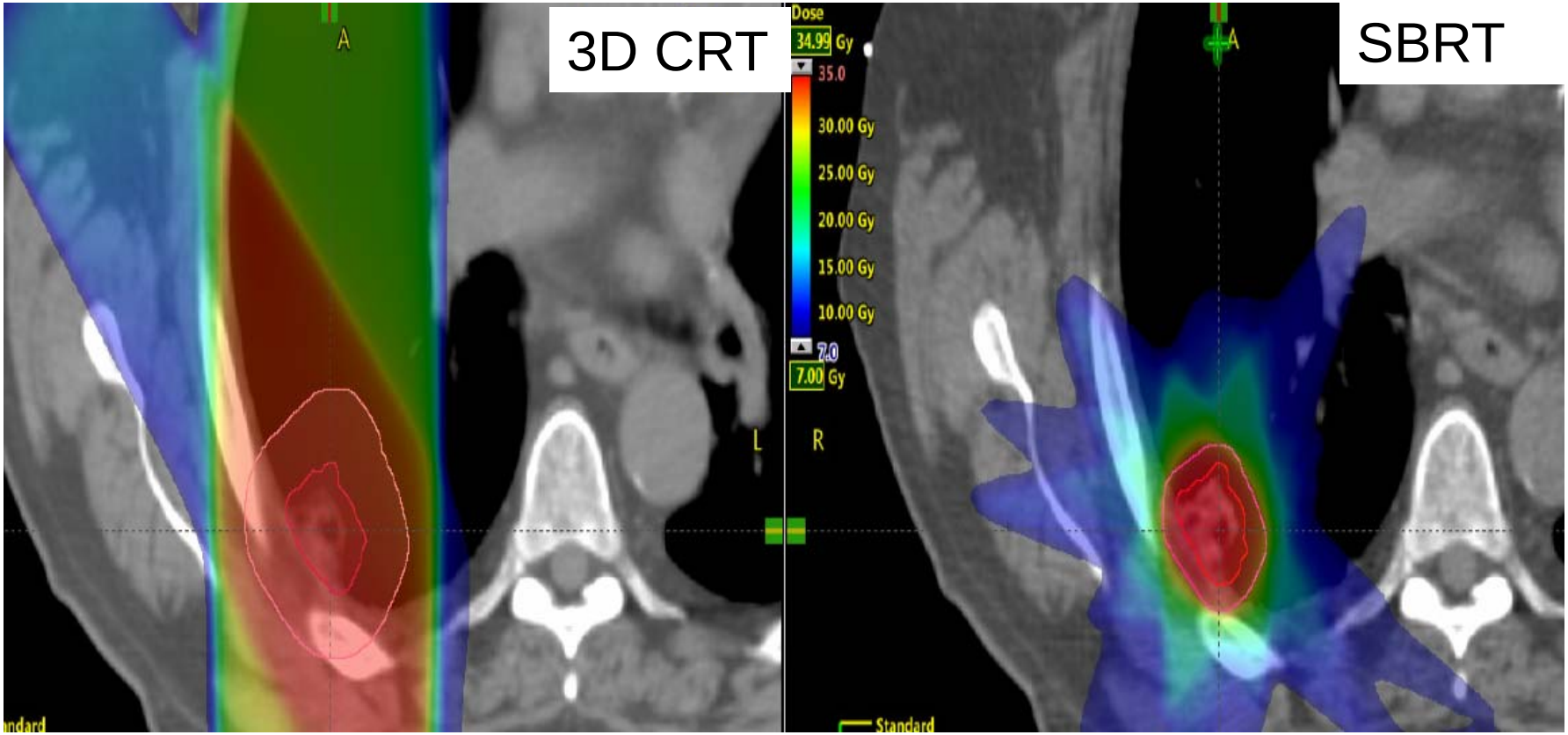
Lung SBRT vs 3DCRT

- 50% Isodose Coverage



Lung SBRT vs 3DCRT

- Low Dose Coverage (7 Gy)



My SBRT Experience

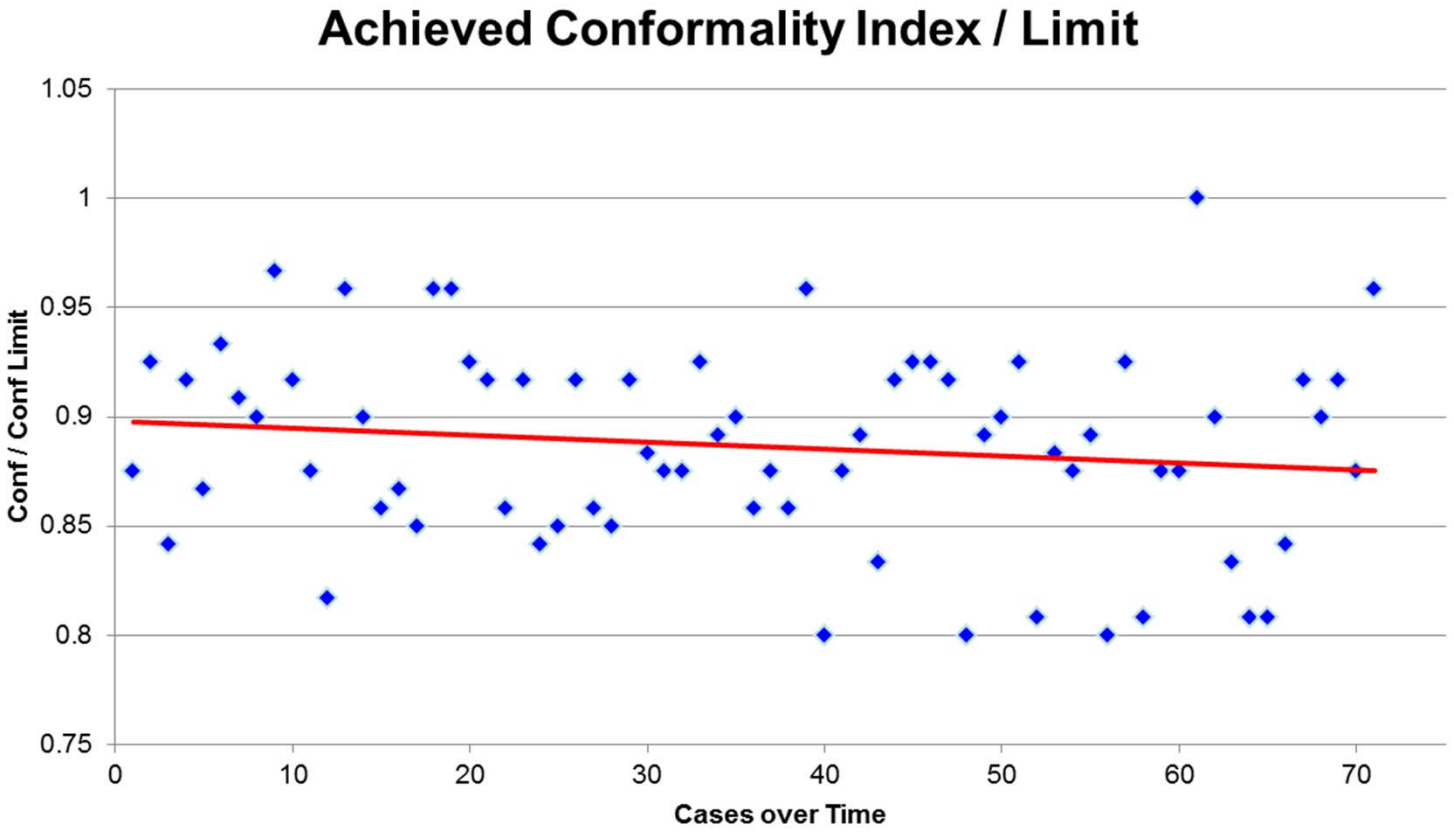
- Started planning Lung SBRT in 2009
- Started planning much more frequently in 2011
- Presentation Data
  - 70 cases
  - 2011 – 2016
  - 3D and VMAT
  - Heterogeneity On and Off

My SBRT Experience

- Data Analysis
  - Parameters vs Time – did I get any better?
  - Parameters vs Technique – is VMAT better?
  - Parameters vs Calculation – is Heterogeneity better?
  - Parameter vs Patient Characteristics – is there a relationship between:
    - PTV volume and dose coverage
    - Total lung volume and lung parameters

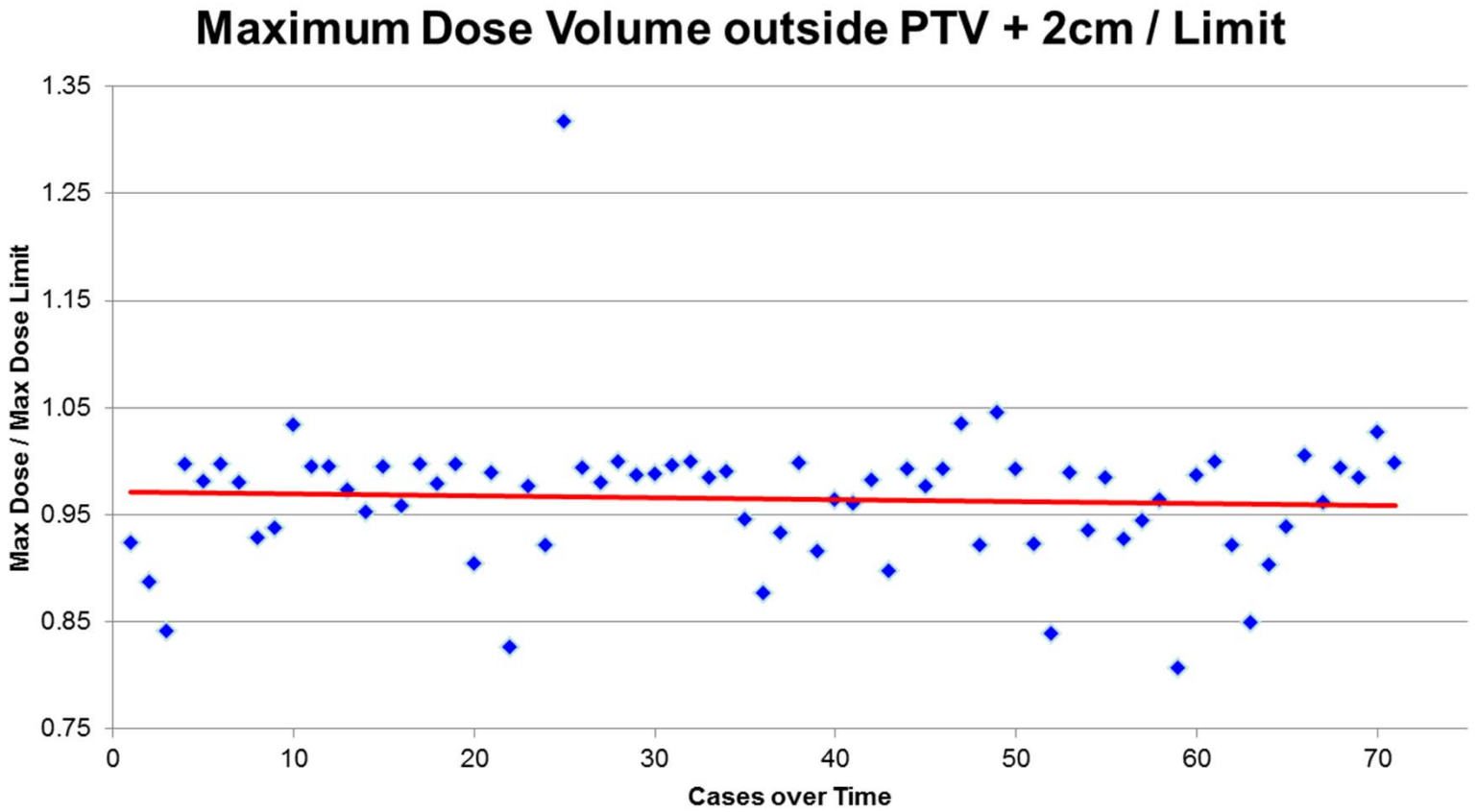
My SBRT Experience

- Did I get any better?



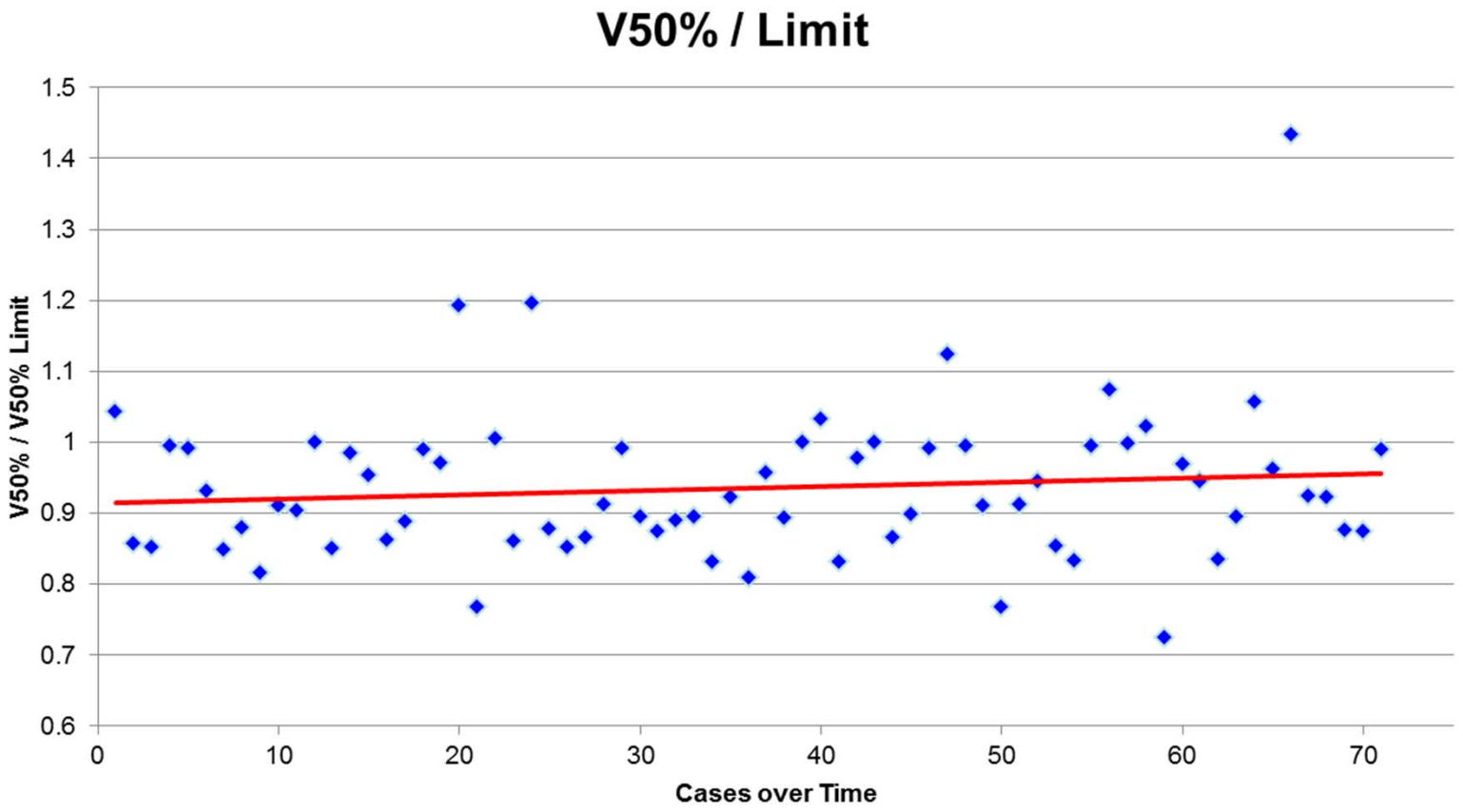
My SBRT Experience

- Did I get any better?



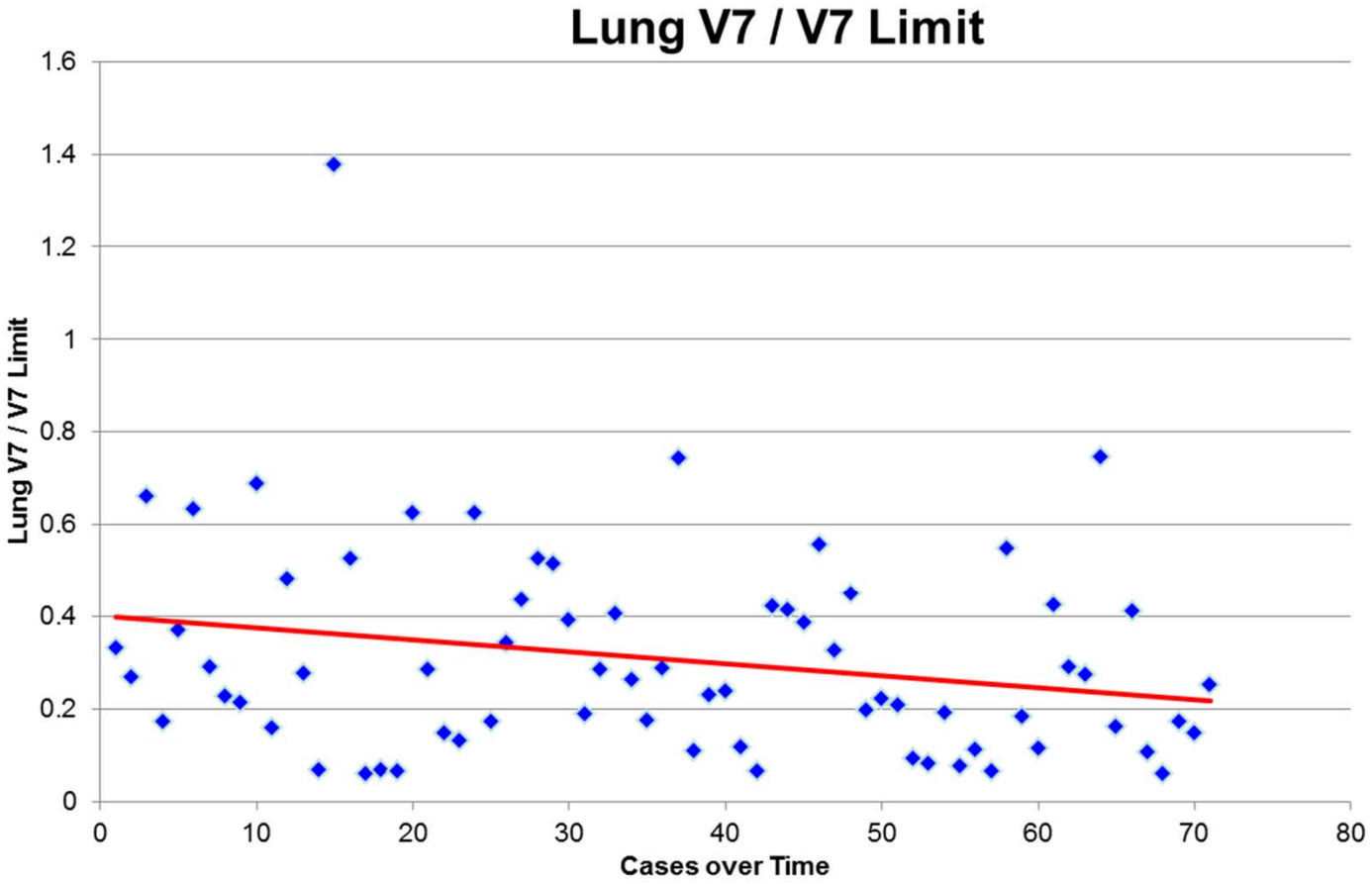
My SBRT Experience

- Did I get any better?



My SBRT Experience

- Did I get any better?



My SBRT Experience

- Is VMAT better than 3D?

	3D (n = 57)	VMAT (n = 13)
Conformality Index / Limit	0.90	0.83 **
Max Dose PTV +2cm / Limit	0.97	0.94
V50% Rx Dose / Limit	0.91	0.99
Lung V7 / Limit	0.27	0.46 **
Lung V20 / Limit	0.30	0.40 **
Time on Treatment Couch	35.5	15

My SBRT Experience

- Is Heterogeneity correction better?
  - We plan patients with or without heterogeneity corrections based upon the protocol we are following and/or the treatment technique

Protocol	Heterogeneity Correction
RTOG 0236	N
RTOG 0813	Y
RTOG 0915	Y
RPCI I-124407	N
All VMAT cases	Y

My SBRT Experience

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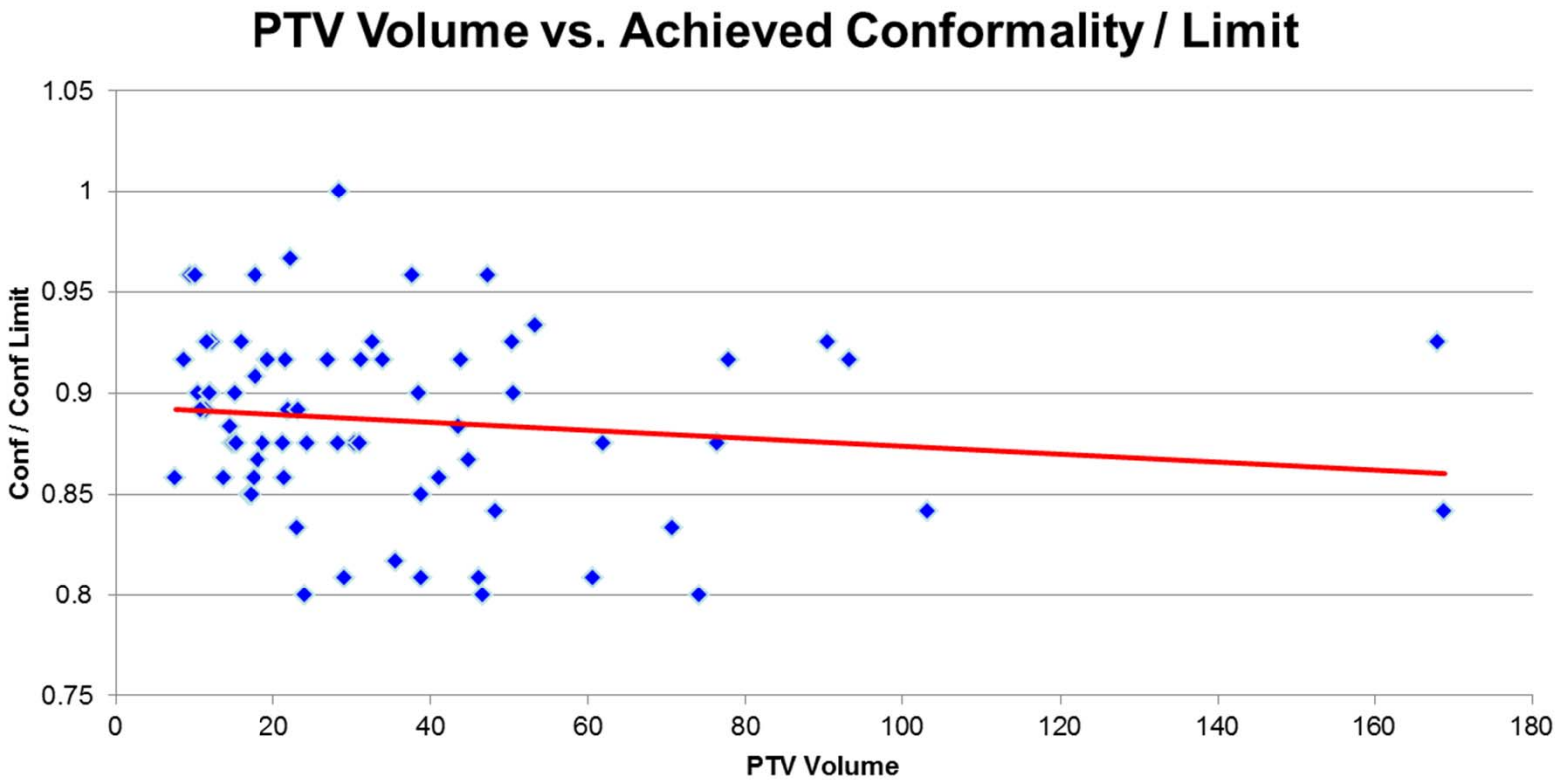
Protocol	Heterogeneity Correction
RTOG 0236	N
RTOG 0813	Y
RTOG 0915	Y
RPCI I-124407	N
All VMAT cases	Y

My SBRT Experience

- Is there a relationship between PTV volume and dose parameters?



My SBRT Experience

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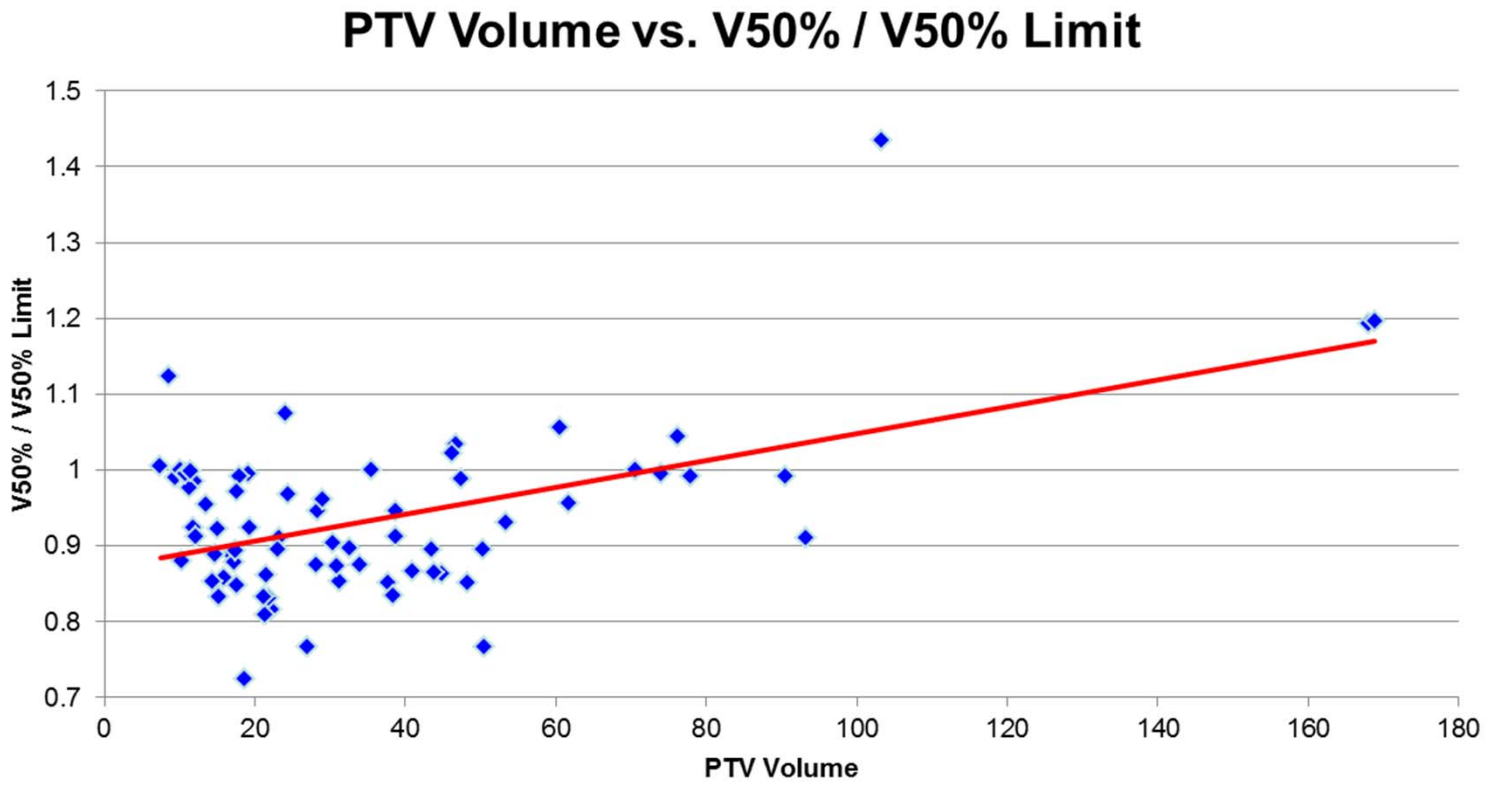

My SBRT Experience

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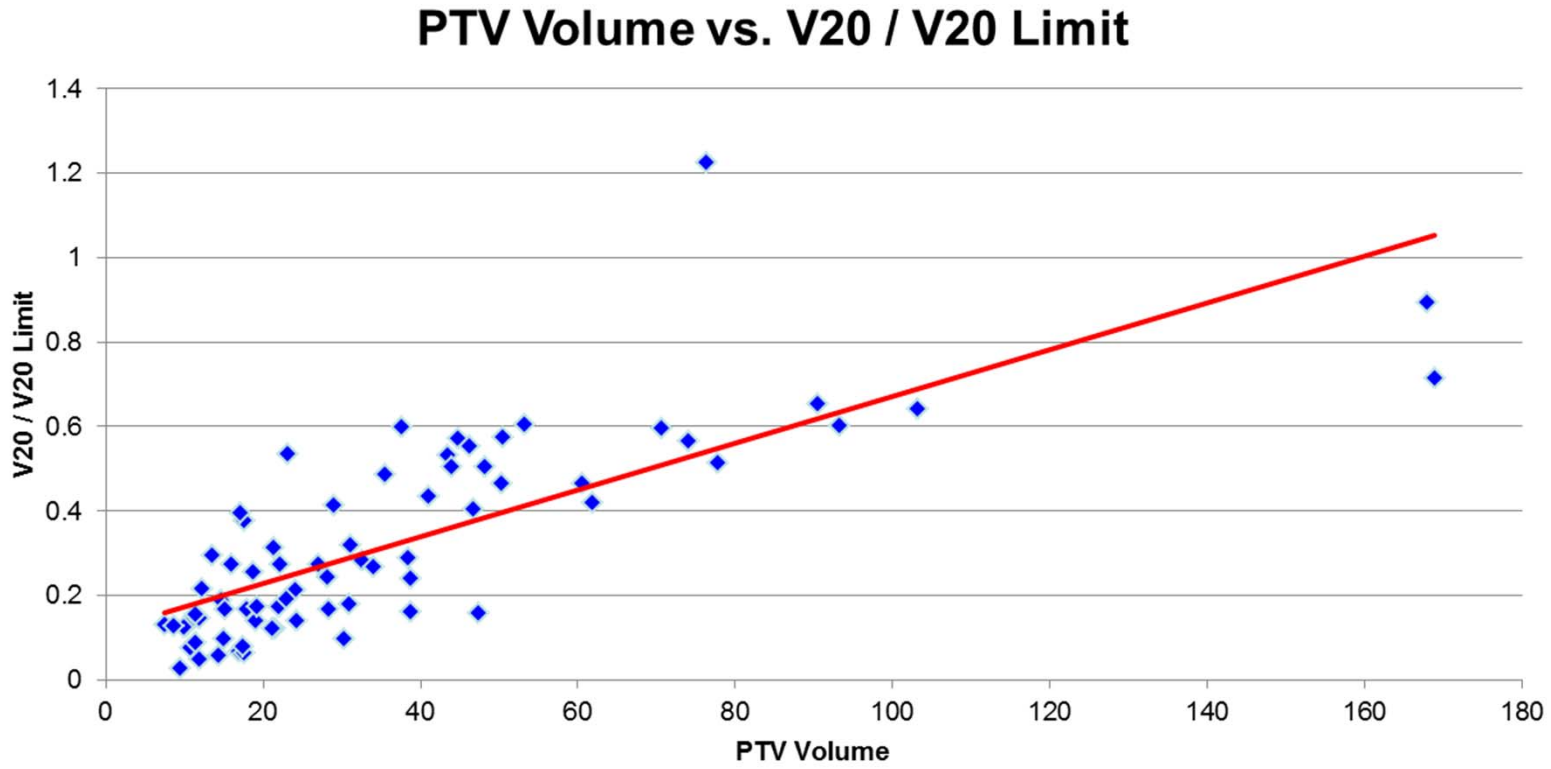
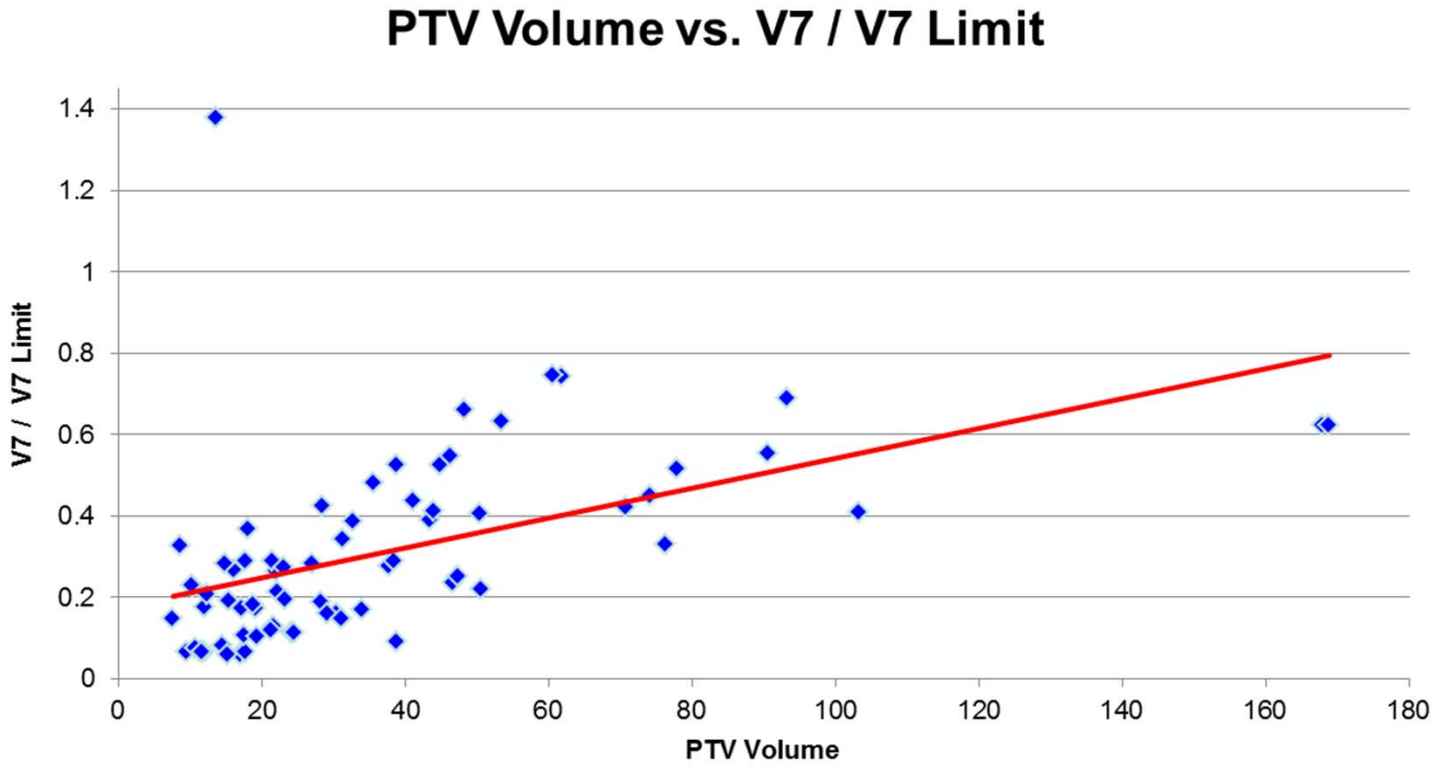


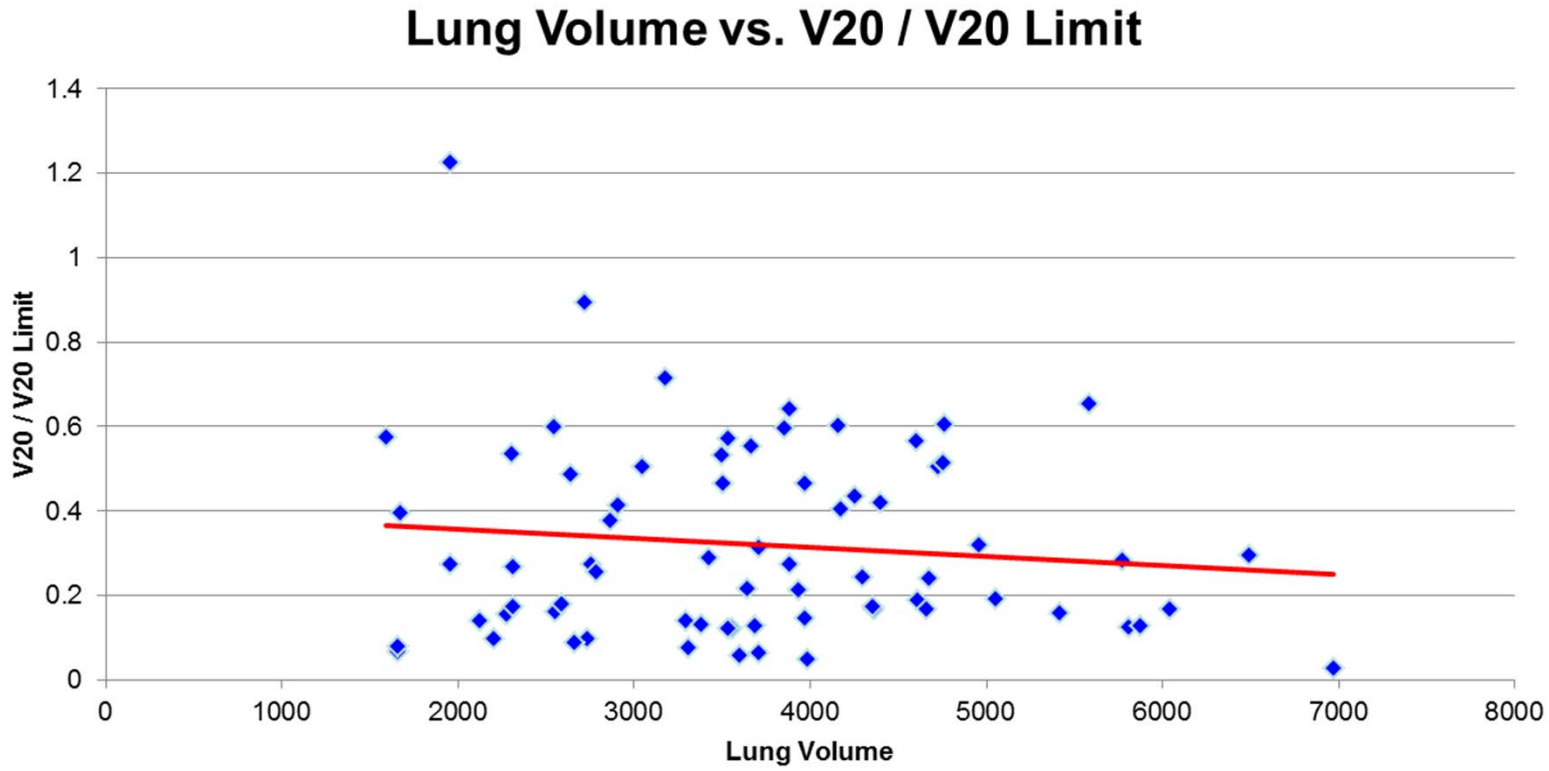
My SBRT Experience

- Is there a relationship between PTV volume and dose parameters?



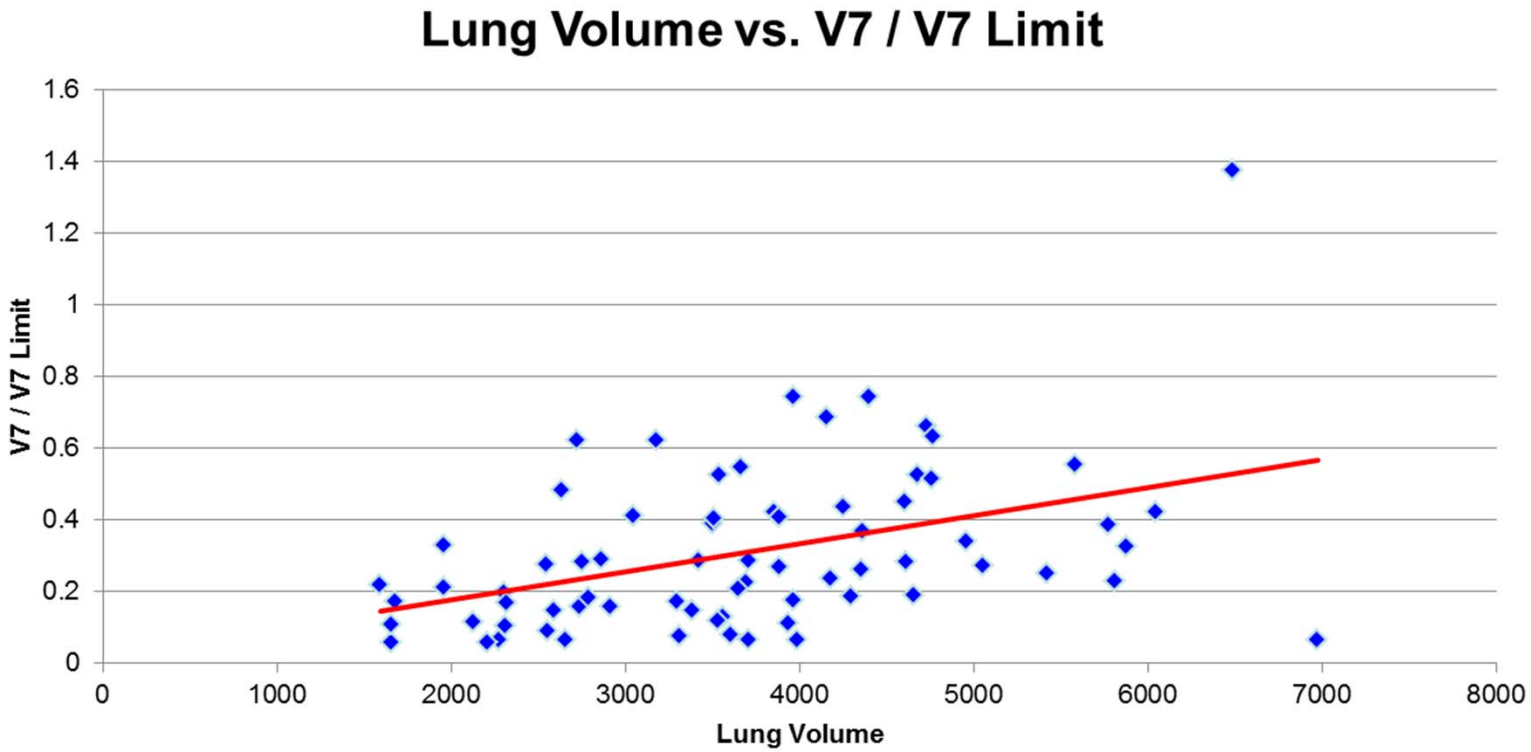
My SBRT Experience

- Is there a relationship between total lung volume and dose parameters?



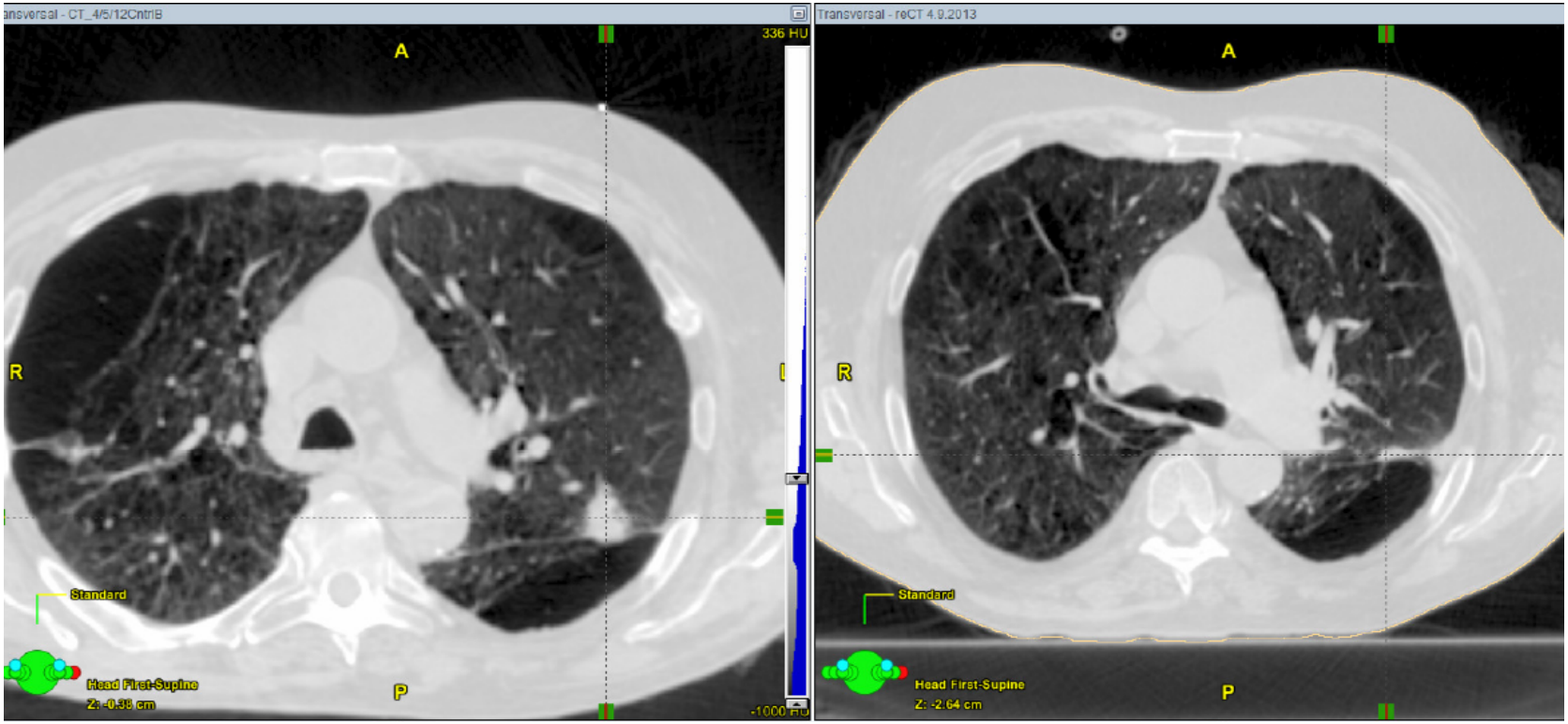
My SBRT Experience

- Is there a relationship between total lung volume and dose parameters?



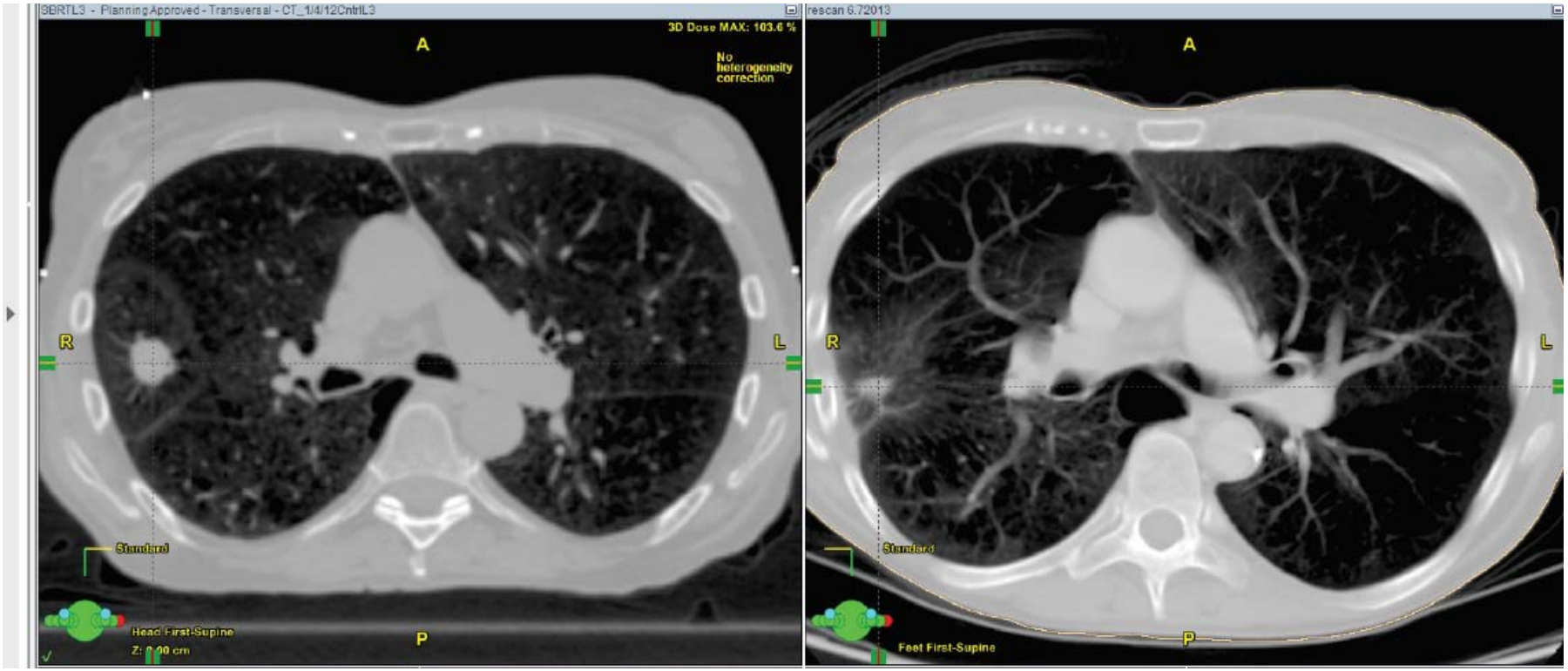
Does SBRT Work?

- 5 months post treatment



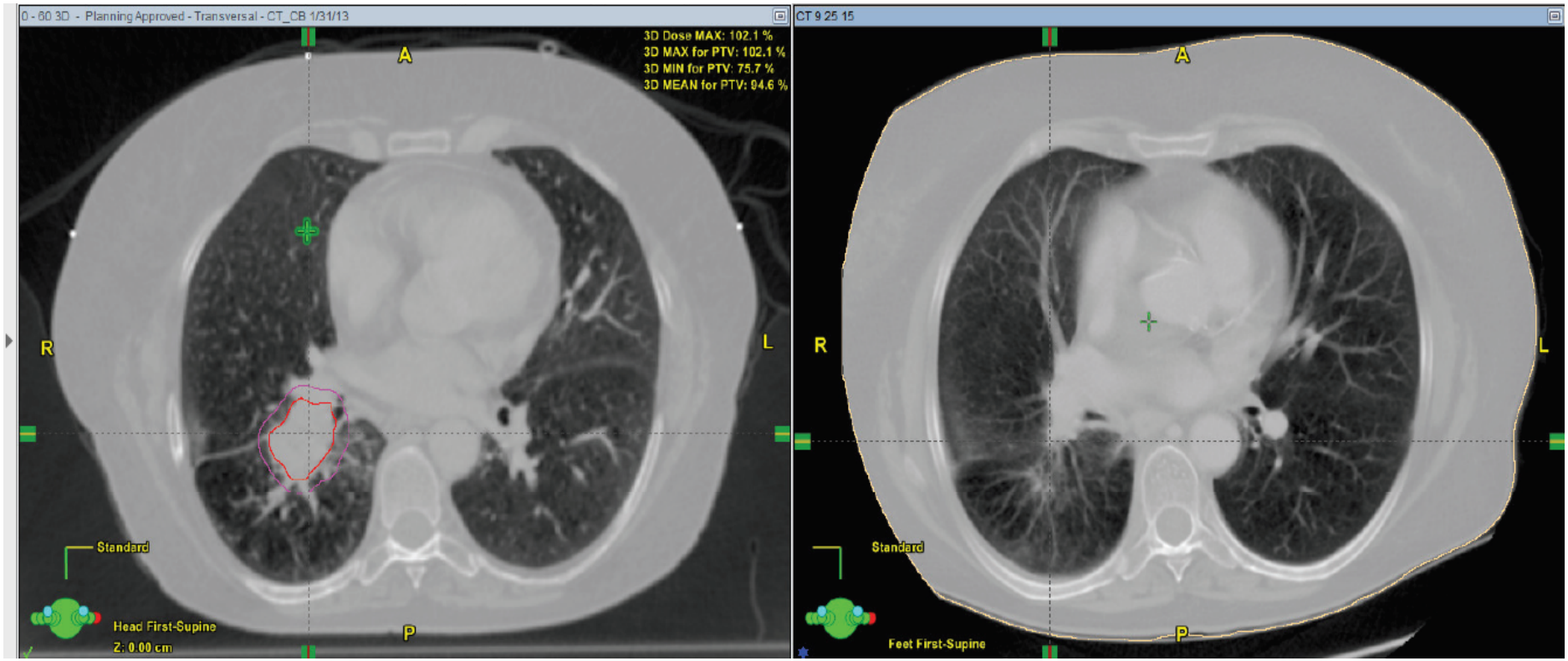
Does SBRT Work?

- 17 months post treatment



Does SBRT Work?

- 31 months post treatment



Conclusions?

- SBRT planning is not for the faint of heart
- Plan quality seems to be largely a factor of the protocol constraints
- There ***"appears"*** to be a relationship between PTV volume and some plan parameters
  - It appears to be more difficult to achieve the V50%, Lung V20 and Lung V7 parameter as PTV volume increases

Advice

- Read the protocols – but sometimes they have English bad
- Make sure you're using the right prescription dose / OAR parameters for the clinical situation
- Do a site visit
- Don't get too freaked out about SBRT planning
- But don't take it lightly

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Thanks

- Rachel Hackett
- Andrew Goraj
- Jeremy Garvin
- Richard Russo
- Anurag Singh
- Jorge Gomez

Thanks

- Callum Hales