What are V20 and V5 and how do we reduce dose to normal lung?

Dr Anusheel Munshi
Senior Consultant, Radiation Oncology,
Fortis Memorial Research Institute, Gurgaon

anusheel.munshi@fortishealthcare.com

Lung cancer radiotherapy

- RT for lung cancer getting increasingly sophisticated
- Usually addition of concurrent chemotherapy in radical treatment of locally advanced tumours
- Side effects tend to increase with poor lung function patients and addition of chemotherapy.
- Need to identify parameters to preempt / reduce toxicity
- V 20 and V 5 are two such parameters

POSITIONING AND IMMOBILIZATION

- Immobilization done in supine position
- Arms: Lateral/ Above head
- Neck: Neutral position and chin to SSN distance to be recorded
- Normal breathing
- Various immobilization boards can be used for better reproducible positions including Vaclocks

CT scan (simulation)

- Contrast iv (with automatic injector if available)
- Thin CT slices (3-5 mm) preferable
- Cricoid cartilage to L2 region
- Must to include entire volume of both lungs in the scan

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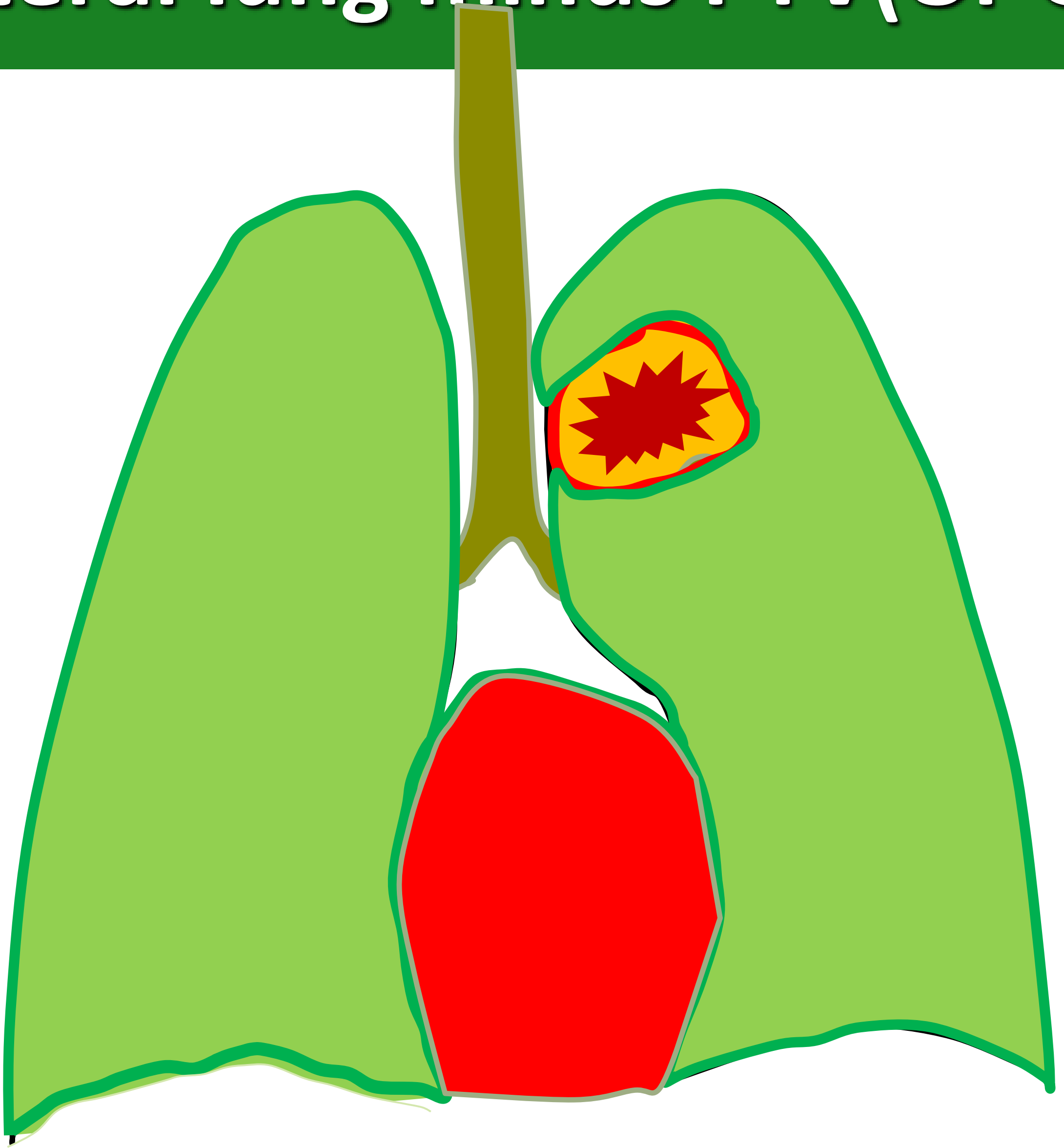
Lung as an OAR

Volumes while contouring lung as OAR

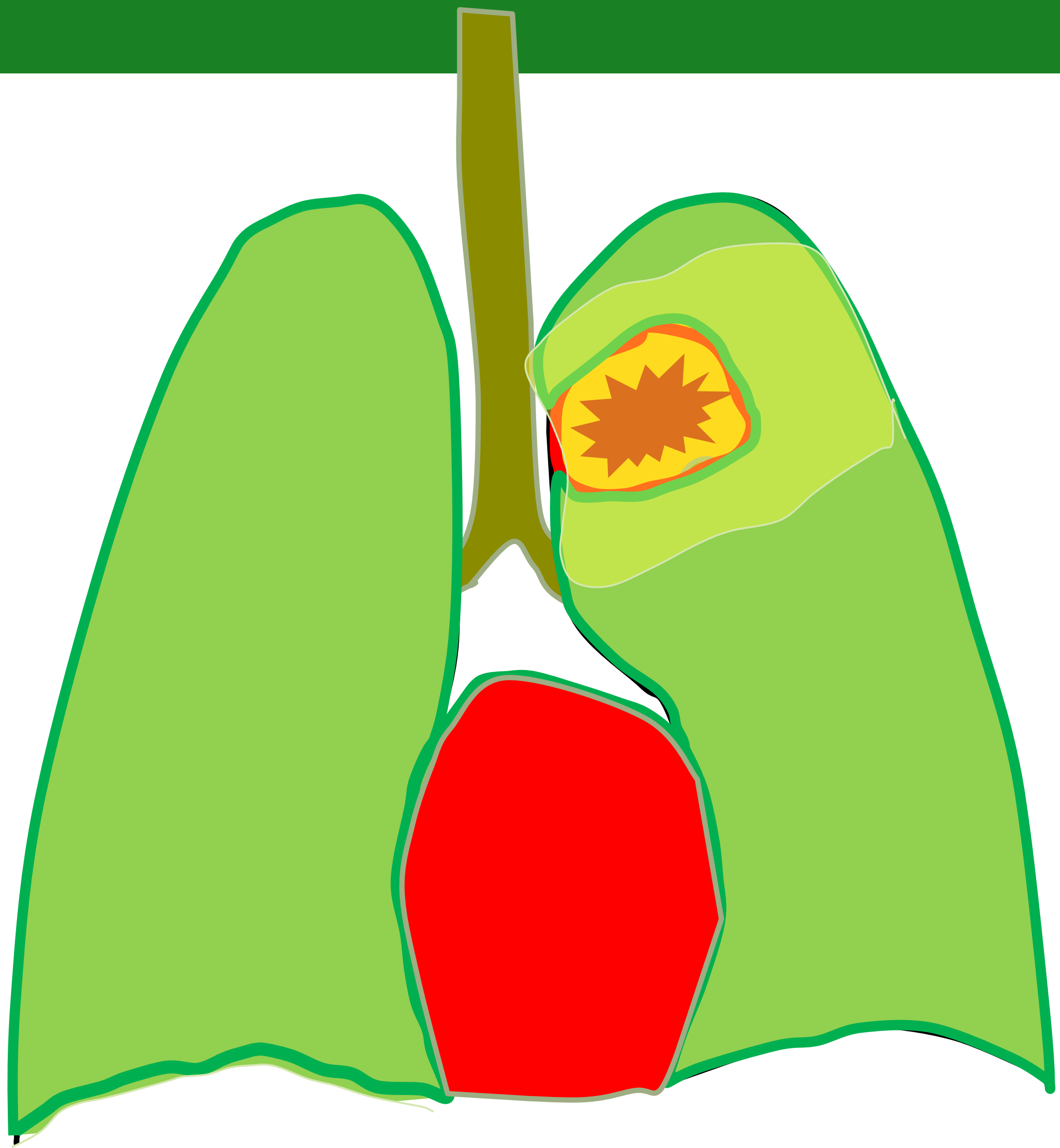
- Need to select the optimal CT window settings (Lung window)
- W = 1600 and C=-600 for parenchyma
- Contour each lung separately
- Contour GTV, CTV and PTV
- Using Boolean function , generate lung OAR

- **Lung OAR= (Left lung + Right Lung) - PTV**

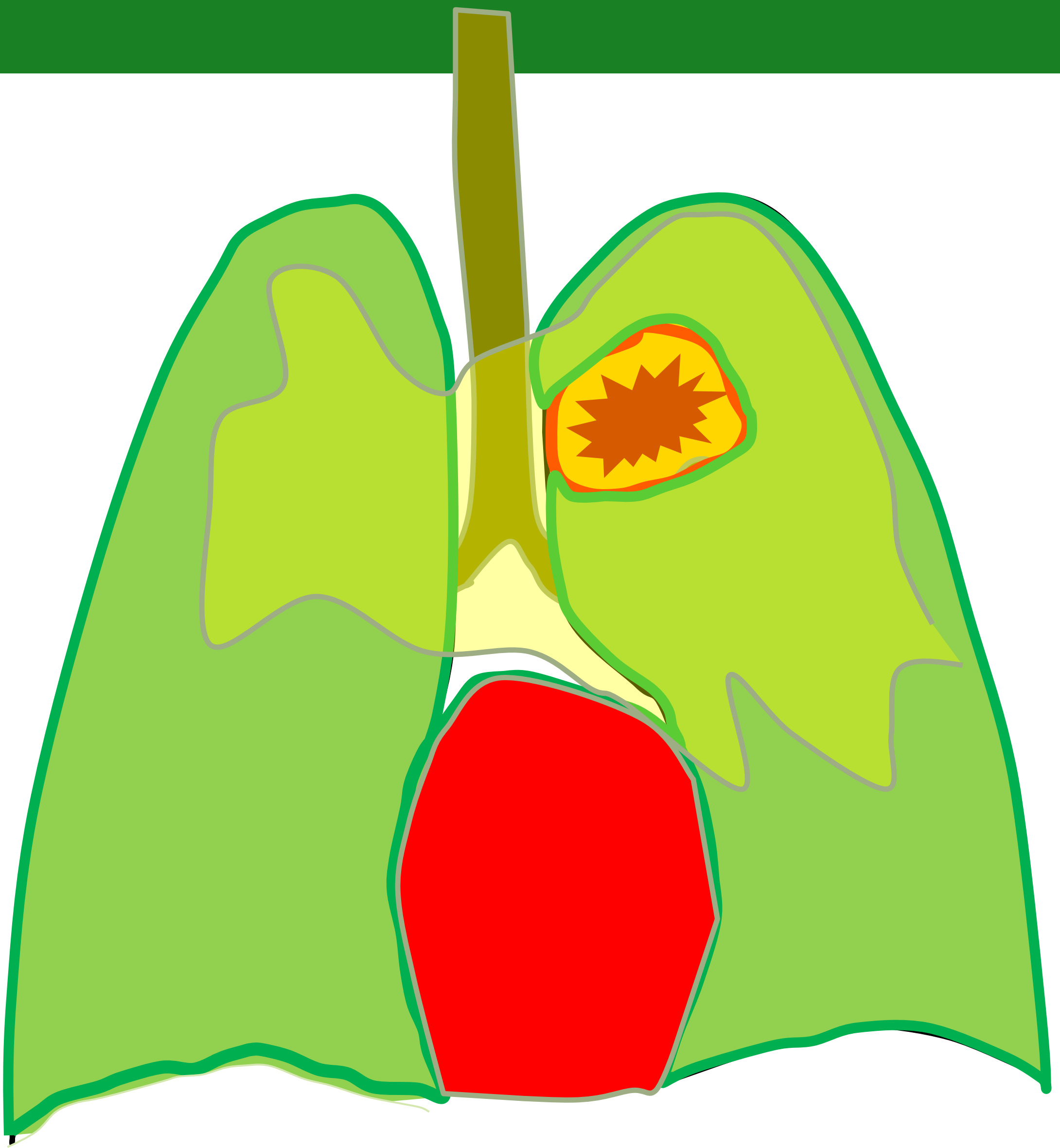
Bilateral lung minus PTV(Or GTV)



V 20



V 5



Basic Definitions

- V 20 = Volume of (B/L lung – PTV) receiving 20 Gray OR MORE / Total volume of B/L Lung – PTV

  (represents intermediate dose area)

- V 5 = Volume of (B/L lung – PTV) receiving 5 Gray OR MORE / Total volume of B/L Lung – PTV

  (represents low dose area)

Normal tissue constraints for Lung

- V 20 <35%
- V 5 < 60%

V 5

- Represents area of lung receiving low /very low dose RT
- Gained in importance in IMRT era
- Especially important in techniques such as VMAT and Tomotherapy which give rotational therapies
- Another way to emphasising that low dose areas with IMRT are as equally important.

Dose/Volume constraints

Dose limits for OARs	3D-CRT (RTOG 0617)	3D-CRT (RTOG 0972/CALGB 36050)	SBRT (RTOG 0618, 3 fx)	SBRT (ROSEL European trial, 3 or 5 fx)
Spinal cord (point dose)	Point dose ≤50.5 Gy	Any portion ≤50 Gy	≤18 Gy (6 Gy/fx)	18 Gy (3 fx) 25 Gy (5fx)
Lung	Mean lung dose ≤20 Gy, V_{20} ≤37%	V_{20} ≤35%	V_{20} ≤10%*	V_{20} <5–10%†
Esophagus	Mean dose ≤34 Gy	Not limited	≤27 Gy (9 Gy/fx)	24 Gy (3 fx) 27 Gy (5 fx)
Brachial plexus (point dose)	≤66 Gy	Not limited	≤24 Gy (8 Gy/fx)	24 Gy (3 fx) 27 Gy (5 fx)
Heart‡	≤60, ≤45, ≤40 Gy for 1/3, 2/3, 3/3 of heart	≤60, ≤45, ≤40 Gy for 1/3, 2/3, 3/3 of heart	≤30 Gy (10 Gy/fx)	24 Gy (3 fx) 27 Gy (5 fx)
Trachea, bronchus	Not limited	Not limited	≤30 Gy (10 Gy/fx)	30 Gy (3 fx) 32 Gy (5 fx)
Ribs	Not limited	Not limited	Not limited§	Not limited
Skin	Not limited	Not limited	≤24 Gy (8 Gy/fx)	Not limited

Kong et al, IJROBP, 2010

Seminal Publication – V 20

Graham MV, Purdy JA, Emami B, et al. Clinical dose-volume histogram analysis for pneumonitis after 3D treatment for non-smallcell lung cancer (NSCLC). Int J Radiat Oncol Biol Phys 1999;45:323-329.

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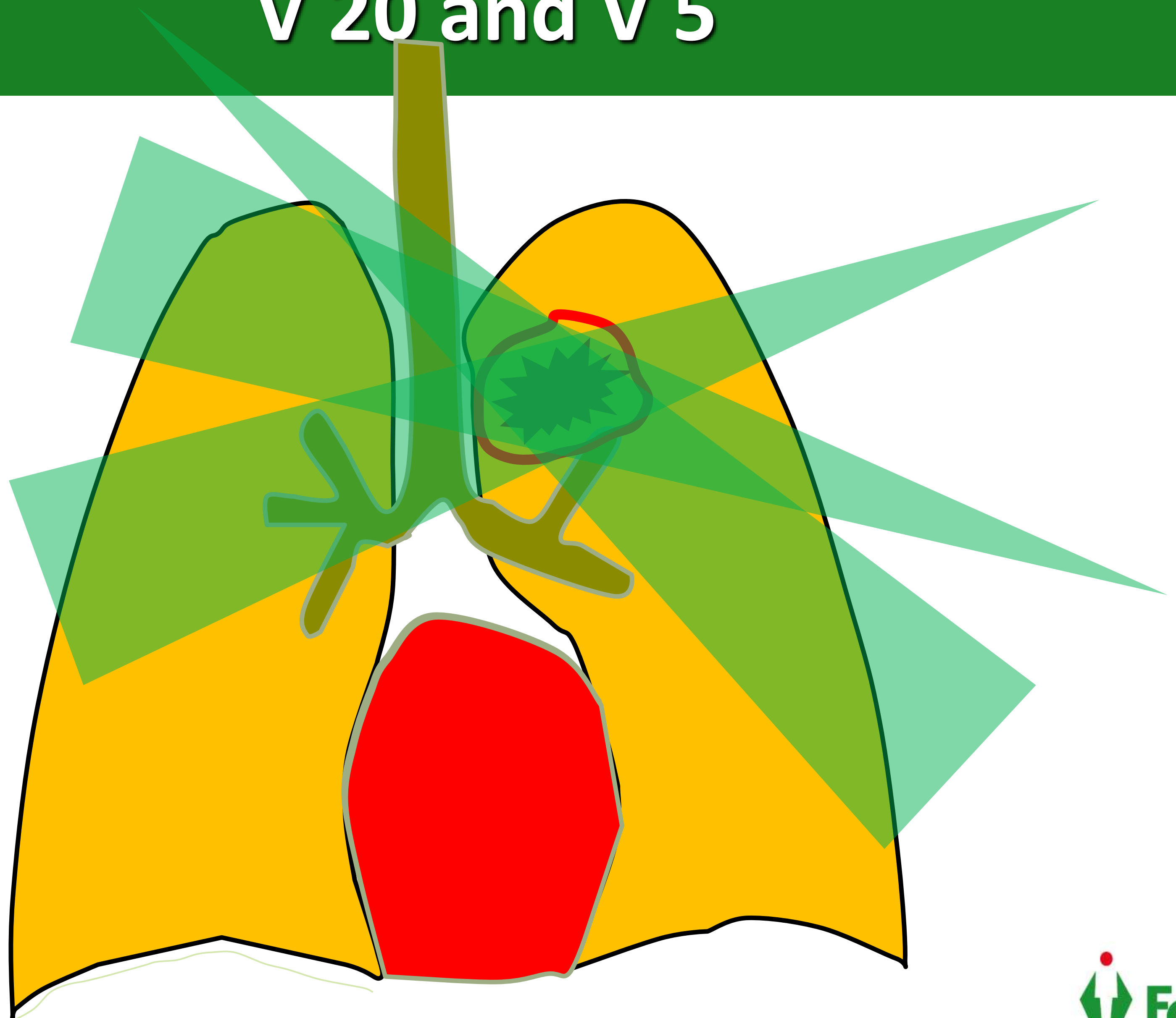
Quiz time

- If we use B/L lung Minus GTV (instead of B/L lung minus PTV), V 20 shall
- A) Fall
- B) Increase
- C) Variable effect
- D) No effect

- Ans: B) Increase

V 20 and V 5



Elevated V 20 and V 5

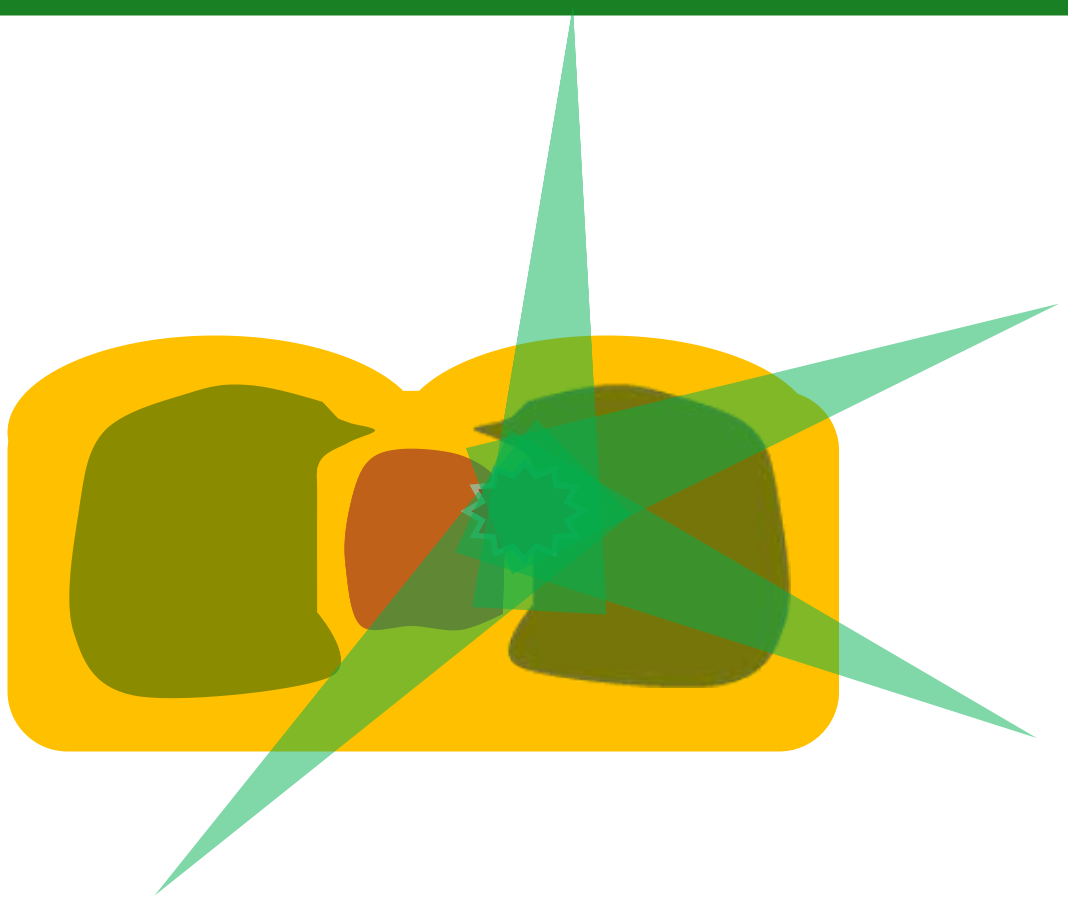
- Truly elevated V 20 and V 5
  - Large PTV
  - Poor planning

- Spurious elevation of V 20 and V 5
  - Lung not contoured properly (portions left out)
  - Incorrect window used
  - PTV not subtracted out from bilateral lungs

Means to reduce V 20 (3D CRT)

- Need to have a good measure of tumour location and likely volumes
- Lower lobe tumours likely to have worse dosimetric parameters
- Need to place appropriate beams(beam angles, number)
- Special arrangements in specific tumour positions

Suggested tip for central tumour of lung /esophagus



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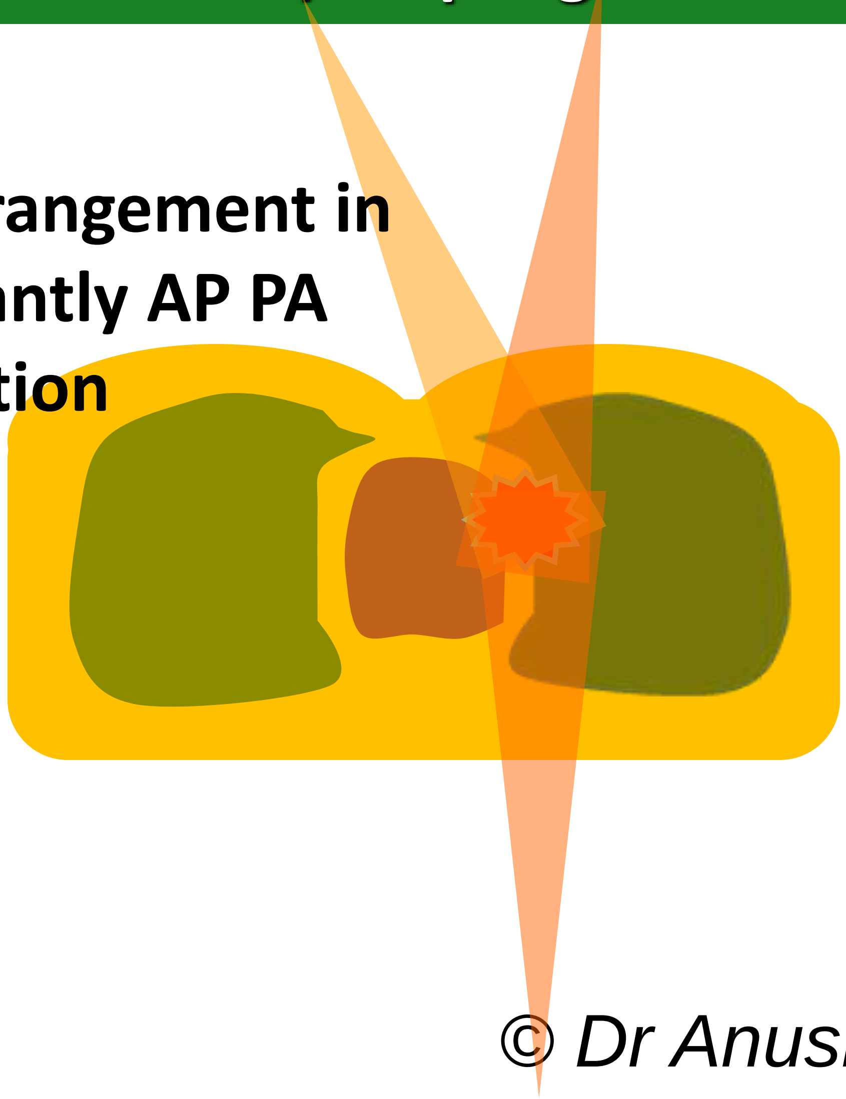
Suggested tip for large volume central tumour of lung /esophagus

Keep beam arrangement in a predominantly AP PA direction



Means to reduce V 20

- Use IMRT instead of 3 DCRT in appropriate cases
- Use of advanced strategies like gating/tracking/breath hold (it shall decrease the PTV and thereby decrease the zone that get 20 Gray)
- Use of ABC device
  - PTV smaller
  - Simulation and treatment in inspiratory position
  - Lungs inflated
  - Lung volume increases and hence denominator more, V 20 falls

DOSE AND VOLUME REDUCTION FOR NORMAL LUNG USING INTENSITY-MODULATED RADIOTHERAPY FOR ADVANCED-STAGE NON–SMALL-CELL LUNG CANCER

Hasan Murshed, M.D.,* H. Helen Liu, Ph.D.,* Zhongxing Liao, M.D.,* Jerry L. Barker, M.D.,* Xiaochun Wang, Ph.D.,* Susan L. Tucker, Ph.D.,† Anurag Chandra, M.D.,* Thomas Guerrero, M.D., Ph.D.,* Craig Stevens, M.D., Ph.D.,* Joe Y. Change, M.D., Ph.D.,* Melinda Jeter, M.D.,* James D. Cox, M.D.,* Ritsuko Komaki, M.D.,* and Radhe Mohan, Ph.D.*

*Division of Radiation Oncology and †Department of Biomathematics, University of Texas M. D. Anderson Cancer Center, Houston, TX

- *41 patients of NSCLC*
- *3 D CRT and IMRT plans(9 F, equidistant, coplanar, generated)*
- *Target, isocentre and prescription same as 3 D CRT*

Parameter	3D-CRT	IMRT	*p*
Thoracic normal tissue V_5 (cm^3)	5658 (3040–11596)	6929 (2759–10788)	0.006
Thoracic Normal Tissue V_{10} (cm^3)	4905 (2550–8751)	4931 (2066–8722)	0.636
Thoracic Normal Tissue V_{20} (cm^3)	3919 (1919–6776)	3398 (1509–6535)	0.001
Thoracic Normal Tissue V_{30} (cm^3)	3212 (1560–5489)	2673 (1242–5402)	<0.0001
Thoracic normal tissue V_{40} (cm^3)	3213 (1560–5489)	2673 (1242–5402)	<0.0001
Thoracic normal tissue integral dose (J)	180 (88–311)	185 (72–13511)	0.781

V 10 and V20 reduced by 7% and 10% respectively

Murshed, IJROBP, 2003

Evolution of Radiation Oncology- Sharp Gun but a blurred target

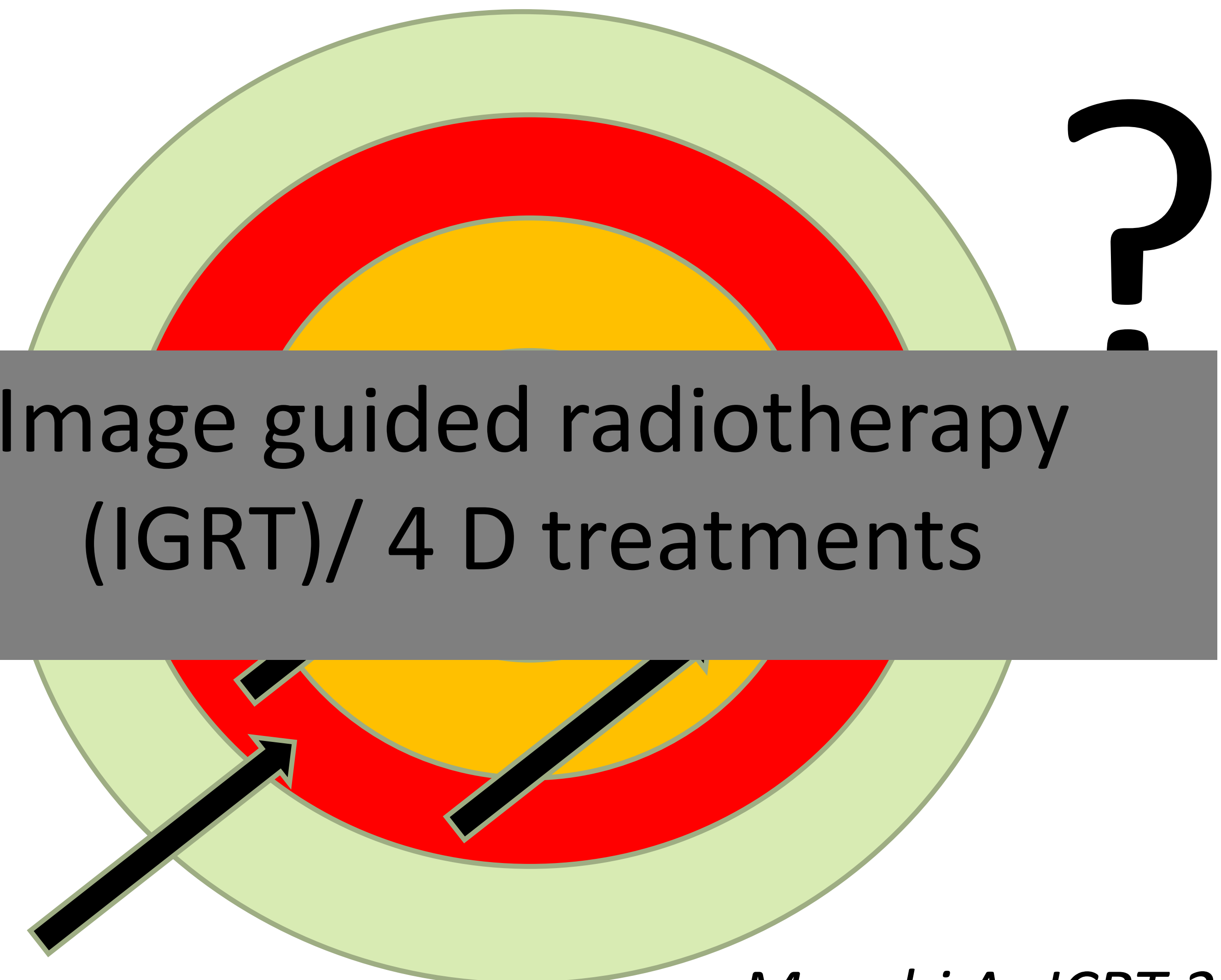
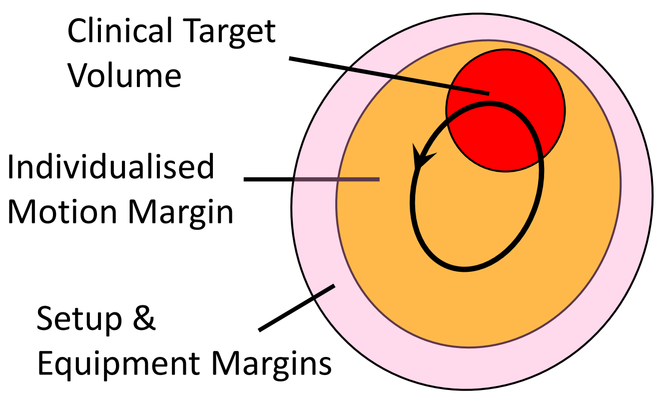


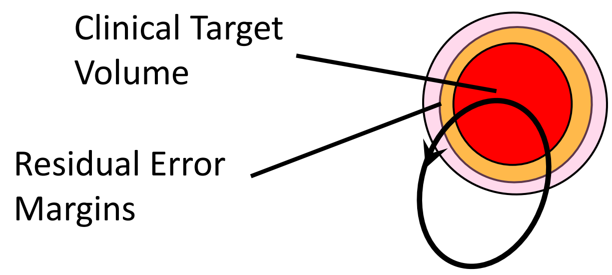
Image guided radiotherapy (IGRT)/ 4 D treatments

Munshi A, JCRT 2010

IGRT- 4 D aspects



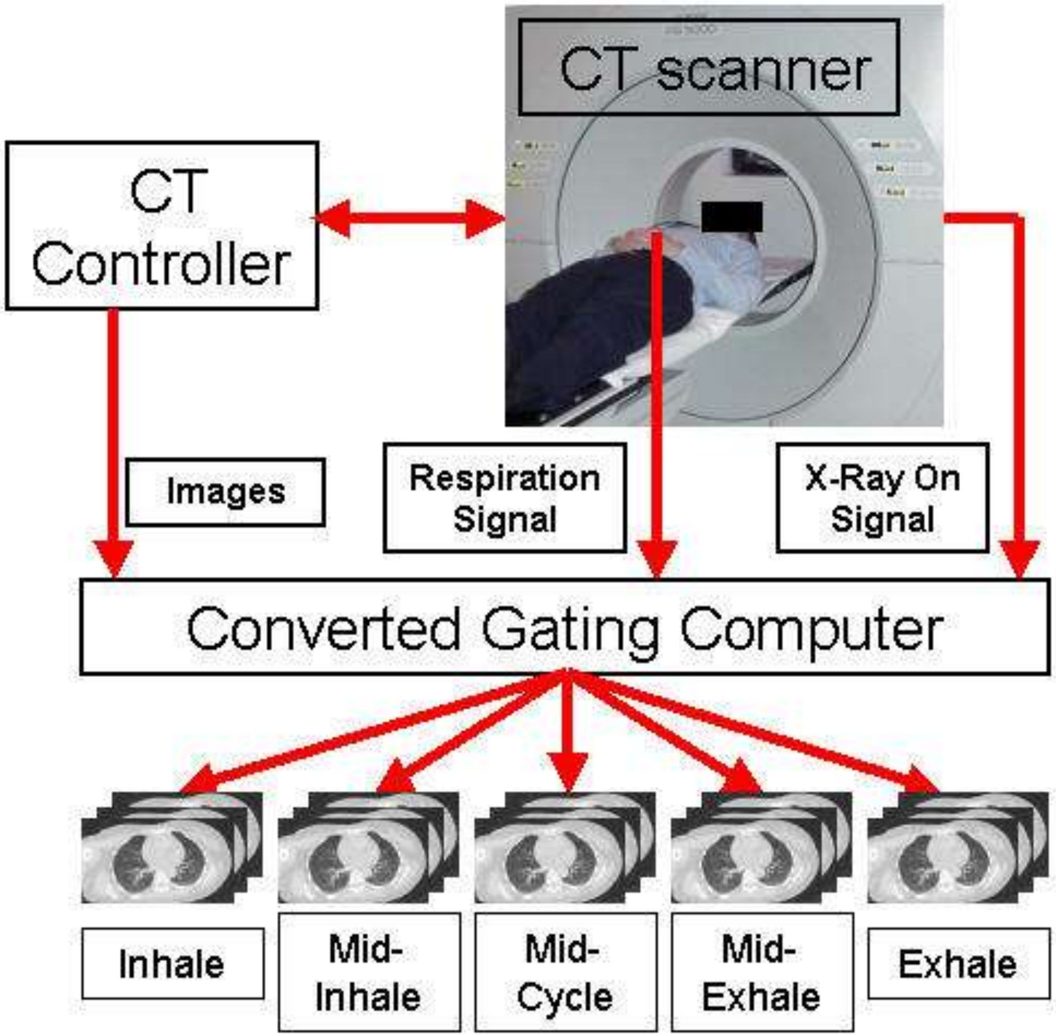
Planning Target Volume



Target tracking Treatments

- Further ensuring the Planned dose and the treatment dose similarity
- Removal of motion encompassing margins may reduce normal tissue dose
- Reduction in normal tissue dose may facilitate tumour dose escalation
- Higher doses delivered to the tumour could result in an improved cure rate

4D CT simulation



pp. 110–115, 2010

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CLINICAL INVES Lung

ADDI
CONSTRA SCLC

SARA RAME MPEO,[†]
GERA
F
ANG

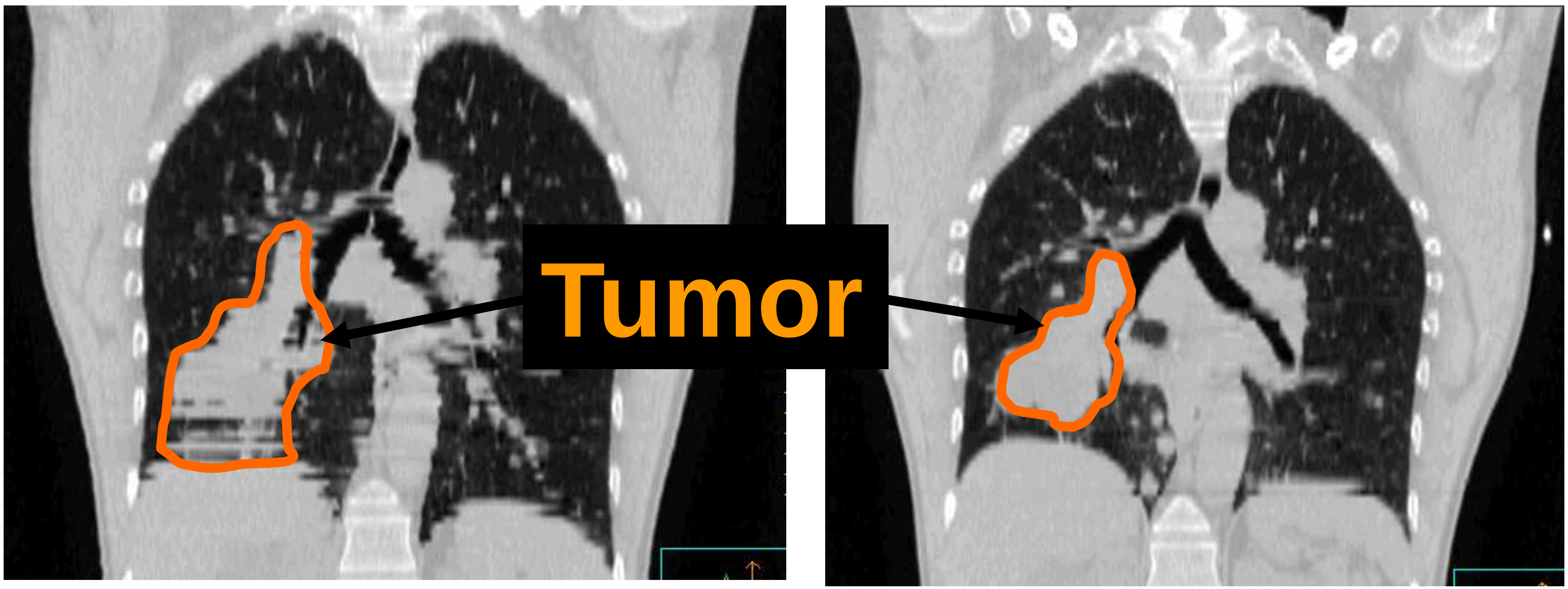
* Radiotherapy Uni sity, Rome,
Italy; [†] Department Rome, Italy;
[||] Lung Cancer Unit partment of
Thoracic Surgery, Catholic University, Rome, Italy

Table 4. Risk groups of patients according to ipsilateral constraints

Variable	Cutoff	Actuarial incidence of lung toxicity of Grade 2 or higher (Common Toxicity Criteria, version 3.0)	p Value (Fisher exact test)
V_{20}ipsi	≤52%	9%	$p = 0.003$
	>52%	46%	
V_{30}ipsi	≤39%	8%	$p = 0.004$
	>39%	38%	
MLDipsi	≤22 Gy	7%	$p = 0.04$
	>22 Gy	23%	

Abbreviations: V_{20}ipsi = percentage of ipsilateral lung volume exceeding 20 Gy; V_{30}ipsi = percentage of ipsilateral lung volume exceeding 30 Gy; MLDipsi = ipsilateral mean lung dose.

Effect of Gated/4 D imaging



Conventional | With gated imaging

Keall *et al* Aust Phys Eng Sci Med 2002

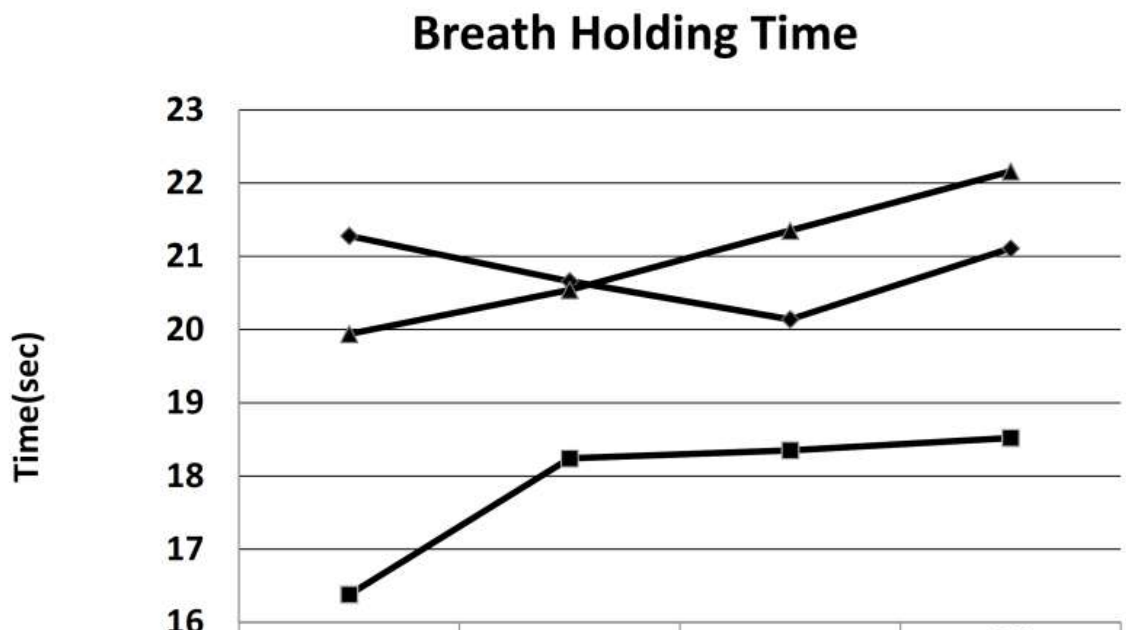
ABC

- Device holds the patients breath in a particular phase of respiration
- Usually the mDIBH level chosen – 70%to 80% of maximum inspiratory capacity
- Suitable breath hold duration chosen – commonly 20 to 25 seconds

ABC

- CT scan acquired (approx two breath holds required to scan the thorax/breast area)
- Treatment planning and execution(4-6 breath holds treatment)

Breath Holding Times



	RT planning	RT Starting	During RT	RT Conclusion
Median DIBH	21.28	20.66	20.14	21.11
Median DEBH	16.38	18.24	18.35	18.52
Median MVBH	19.94	20.54	21.35	22.16

A Munshi et al, Under reivew

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Overview

Stereotactic Conformal Radiotherapy in Non-small Cell Lung Cancer — An Overview

A. Munshi*, R. Krishnatry, S. Banerjee, J.P. Agarwal

Department of Radiation Oncology, Tata Memorial Hospital, Mumbai, India

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Abstract

Stereotactic conformal radiotherapy is an established technique in treating cranial lesions and has made significant inroads in the treatment of extracranial sites as well. Early stage non-small cell lung cancer is one such site. This overview assesses the results that have been achieved with stereotactic conformal radiotherapy in non-small cell lung cancer so far and compares its efficacy with surgical and other non-surgical modalities.

Key words: Carcinoma; lung; radiotherapy; stereotactic

Body Fix solution

ABC outcomes

- 18 NSCLC patients from RMH , UK
- Mean reduction in GTV 25% ($p= 0.003$).
- Compared with free-breathing, ABC reduced
- V(20) by 13% ($p=0.0001$)
- V(13) by 12% ($p=0.001$)
- MLD by 13% ($p<0.001$)

Brada et al IJROBP 2010

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Outcomes of Respiratory Gating

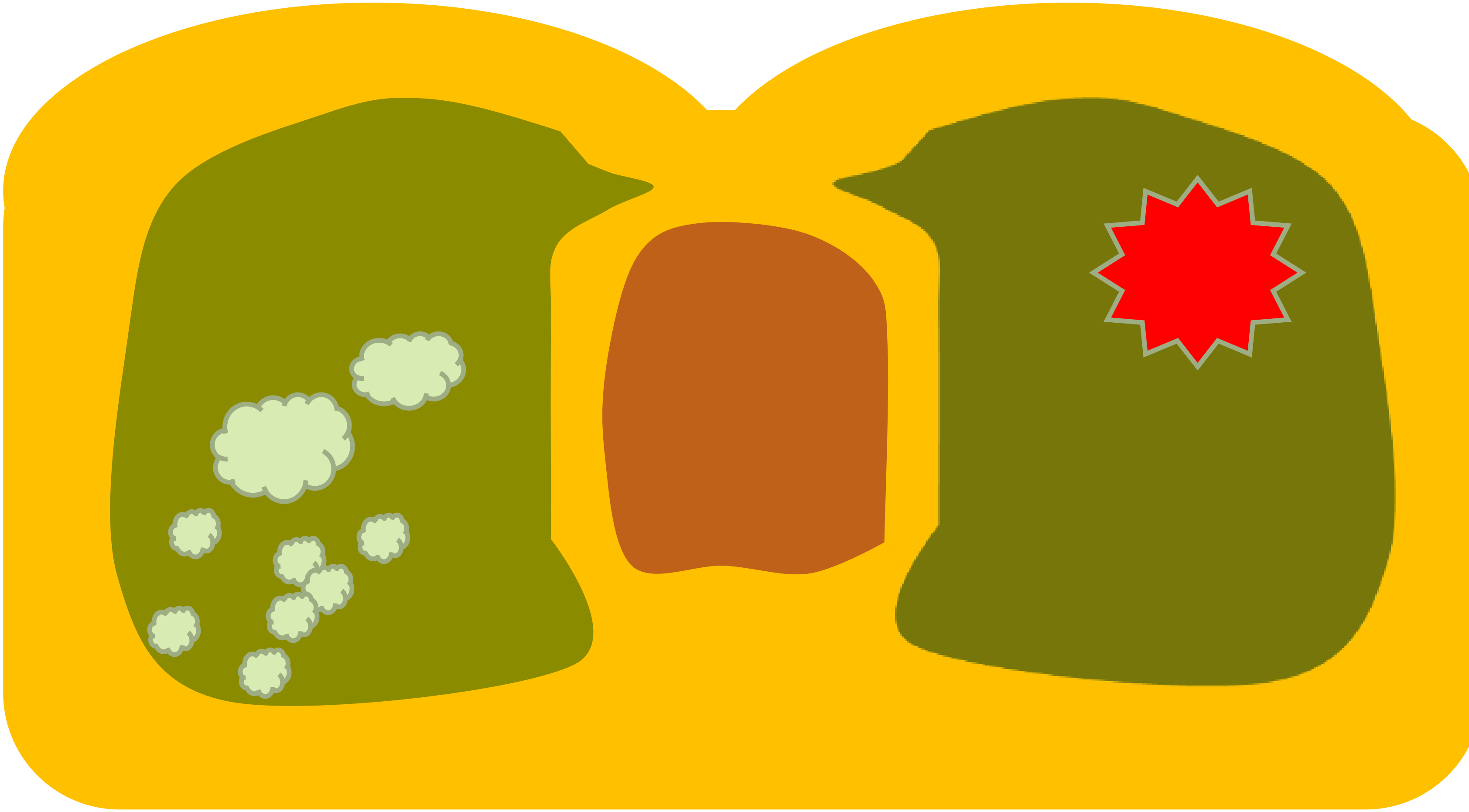
- Twenty patients with CT under assisted breath hold at normal inspiration, at full expiration and under free breathing
- 13 of 20 patients had GTVs of <100 cm3
- Benefit of V20 reduction only with small tumours (volume of GTV < 100 cm3) and significant tumour motion

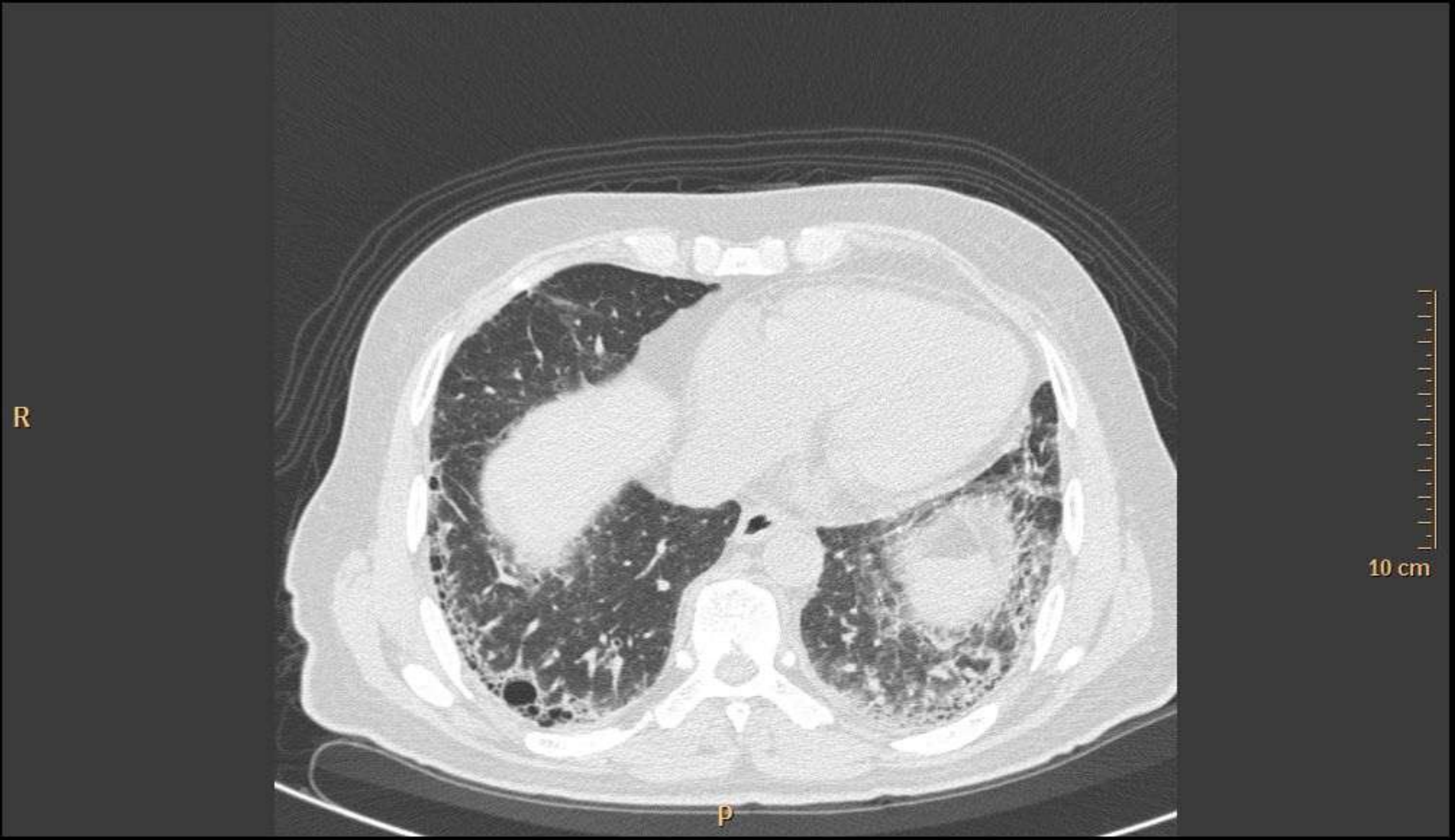
Starkschall IJROBP 2004

Caution!

- V20 and V5 could vary from one planning workstation to another
- Different algorithms may yield variable V 20 and V 5 (Batho, Monte Carlo algorithm)
- Algorithms can be especially important as there is variation in lung density.
- Algorithms derived directly from Monte Carlo, such as superposition-convolution and collapsed cone far superior to algorithms of the past (e.g. the one used in seminal publication)

Drawbacks of V 20/ V 5




R
10 cm
P

Drawbacks of V 20/ V 5

- DVH represents anatomic pulmonary volume, which does not reflect a variety of confounding factors.
- Not a functional parameter (does not take into account lung function)
- Several other factors important in radiation pneumonitis and need to be accounted (PS,concurrent chemo, smoking, age, ….)

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Summary / Conclusions

- V 5 and V 20 are important parameters to see and evaluate during radical radiotherapy of lung cancer
- Need to understand the rationale and benefit of using these parameters
- Be cognizant of the pitfalls of these parameters as well
- Need to rely on a totality of patient/tumour/dosimetric parameters and not one or two factors in isolation

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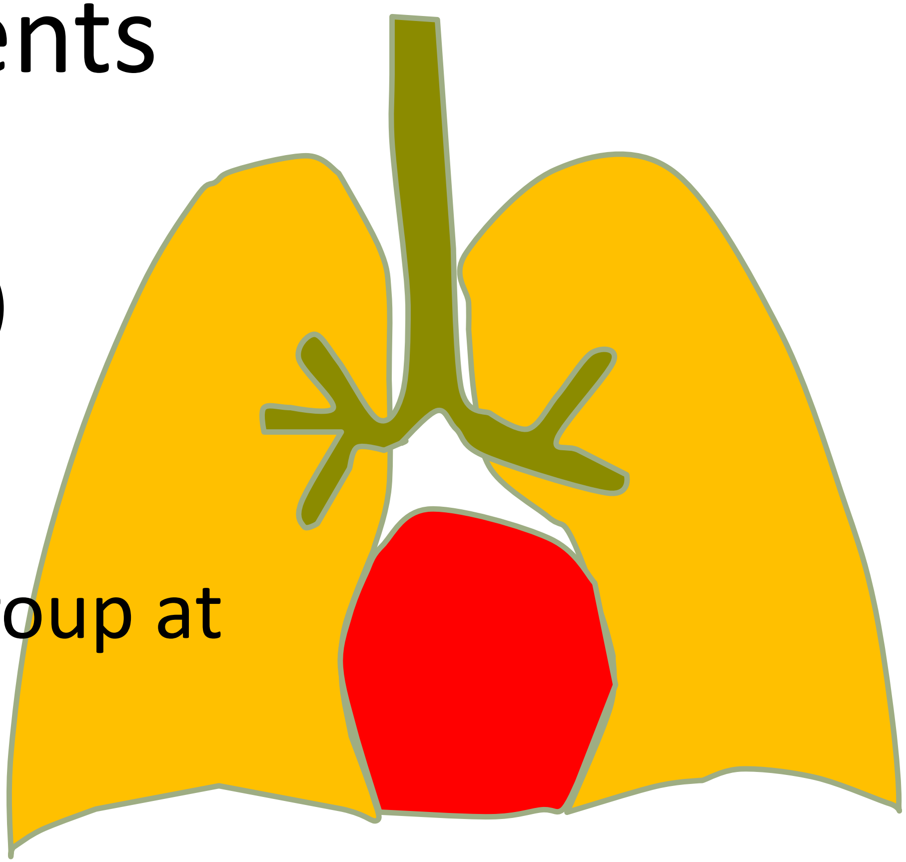
- Fortis Hospital(Gurgaon) Oncology Team

- Lung Cancer Working Group at TMH



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