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

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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
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
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

- \( \text{Lung OAR} = (\text{Left lung} + \text{Right Lung}) - \text{PTV} \)
Bilateral lung minus PTV (Or GTV)
Basic Definitions

- **V 20** = Volume of (B/L lung – PTV) receiving 20 Gray OR MORE
  
  \[
  \frac{\text{Total volume of B/L Lung – PTV}}{}
  \]
  
  *(represents intermediate dose area)*

- **V 5** = Volume of (B/L lung – PTV) receiving 5 Gray OR MORE
  
  \[
  \frac{\text{Total volume of B/L Lung – PTV}}{}
  \]
  
  *(represents low dose area)*
Normal tissue constraints for Lung

- $V_{20} < 35\%$
- $V_{5} < 60\%$
- 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

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

* * *

Kong et al, IJROBP, 2010
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

© Dr Anusheel Munshi
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
41 patients of NSCLC

3 D CRT and IMRT plans (9 F, equidistant, coplanar, generated)

Target, isocentre and prescription same as 3 D CRT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3D-CRT</th>
<th>IMRT</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic normal tissue V₂ (cm³)</td>
<td>5658 (3040–11596)</td>
<td>6929 (2759–10788)</td>
<td>0.006</td>
</tr>
<tr>
<td>Thoracic Normal Tissue V₁₀ (cm³)</td>
<td>4905 (2550–8751)</td>
<td>4931 (2066–8722)</td>
<td>0.636</td>
</tr>
<tr>
<td>Thoracic Normal Tissue V₂₀ (cm³)</td>
<td>3919 (1919–6776)</td>
<td>3398 (1509–6535)</td>
<td>0.001</td>
</tr>
<tr>
<td>Thoracic Normal Tissue V₃₀ (cm³)</td>
<td>3212 (1560–5489)</td>
<td>2673 (1242–5402)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Thoracic normal tissue V₄₀ (cm³)</td>
<td>3213 (1560–5489)</td>
<td>2673 (1242–5402)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Thoracic normal tissue integral dose (J)</td>
<td>180 (88–311)</td>
<td>185 (72–13511)</td>
<td>0.781</td>
</tr>
</tbody>
</table>

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
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

CT Controller

CT scanner

Images

Respiration Signal

X-Ray On Signal

Converted Gating Computer

Inhale  Mid-Inhale  Mid-Cycle  Mid-Exhale  Exhale
Table 4. Risk groups of patients according to ipsilateral constraints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cutoff</th>
<th>Actuarial incidence of lung toxicity of Grade 2 or higher (Common Toxicity Criteria, version 3.0)</th>
<th>p Value (Fisher exact test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{20\text{ipsi}}$</td>
<td>$\leq 52%$</td>
<td>9%</td>
<td>$p = 0.003$</td>
</tr>
<tr>
<td></td>
<td>$&gt; 52%$</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td>$V_{30\text{ipsi}}$</td>
<td>$\leq 39%$</td>
<td>8%</td>
<td>$p = 0.004$</td>
</tr>
<tr>
<td></td>
<td>$&gt; 39%$</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>MLDipsi</td>
<td>$\leq 22\text{ Gy}$</td>
<td>7%</td>
<td>$p = 0.04$</td>
</tr>
<tr>
<td></td>
<td>$&gt; 22\text{ Gy}$</td>
<td>23%</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: $V_{20\text{ipsi}} =$ percentage of ipsilateral lung volume exceeding 20 Gy; $V_{30\text{ipsi}} =$ percentage of ipsilateral lung volume exceeding 30 Gy; MLDipsi = ipsilateral mean lung dose.
Effect of Gated/4 D imaging

Conventional vs. With gated imaging

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
➢ 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

### Breath Holding Time

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>RT planning</th>
<th>RT Starting</th>
<th>During RT</th>
<th>RT Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median DIBH</td>
<td>21.28</td>
<td>20.66</td>
<td>20.14</td>
<td>21.11</td>
</tr>
<tr>
<td>Median DEBH</td>
<td>16.38</td>
<td>18.24</td>
<td>18.35</td>
<td>18.52</td>
</tr>
<tr>
<td>Median MVBH</td>
<td>19.94</td>
<td>20.54</td>
<td>21.35</td>
<td>22.16</td>
</tr>
</tbody>
</table>

*A Munshi et al, Under review*
Overview

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

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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.

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Key words: Carcinoma; lung; radiotherapy; stereotactic
Body Fix solution
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
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
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, ....)
Summary / Conclusions

➢ V5 and V20 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
Acknowledgements

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Thank You