Target volume delineation in lung cancers

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Road map

- GTV lung tumours
- CTV lung tumours
- GTV nodes
- CTV nodes
- Target volume in postoperative case
GTV lung tumour

- Anatomy of lungs and mediastinum
- Imaging features
- Limitations of current imaging techniques
Anatomy of lungs

Right Lung
- Apex
- Upper lobe
- Middle lobe
- Hilum
- Lower lobe

Left Lung
- Apex
- Upper lobe
- Lingula
Bronchopulmonary segments
Anatomy of thorax supraaortic level I

- Rt. Brachioceph vein
- Brachioceph trunk
- Lt. Brachioceph vein
- CCA
- Sub clavian art
Supraaortic level II

- Rt. Brachiocephalic vein
- Lt. Brachiocephalic vein
- Brachiocephalic trunk
- CCA
- Subclavian artery
Aortic arch
Left pulmonary artery and carina
Right pulmonary artery

SVC
Rt pulmonary artery
Rt Bronchus
Lt pulmonary artery
Lt bronchus
Left atrium

- Rt. atrium
- Rt. ventricle
- Lt. Ventricle
- Lt. atrium
- Descending aorta
Left ventricle

Rt. Ventricle
Rt. atrium
Lt. ventricle
Lt. atrium
Descending aorta
Supradiaphragmatic level

- Liver
- Rt. Ventricle
- Rt. atrium
- Lt. ventricle
- Lt. atrium
- Descending aorta
**Imaging features: T1**

**T1:** Tumor < 3 cm,  
Not proximal to lobar bronchus  
Surrounded by lung or visceral pleura
Imaging features: T2

T2: Tumor > 3 cm,
main bronchus > 2 cm from carina
Visceral pleura invasion
Atelectasis, consolidation not inv entire lung
Imaging features: T3

T3: any size with inv chestwall/med pleura/parietal pericardium/diaphragm
main bronchus inv <2cm from carina
Atelectasis, consolidation entire lung

Lesion abutting chest wall and invading the visceral pleura,
Endobronch lesion at Lt. UL bronchus.
Left upper lobe collapse
Atelectasis ext to hilar region
Imaging features: T4

T4:
- Invasion of mediastinum, heart, great vessels, trachea, esophagus, vertebral body, carina
- Malignant pleural or pericardial effusion
- Satellite tumor nodules

Mass obstructing left upper lobe bronchus & left upper lobe collapse, and pleural effusion.
Imaging features: N1

N1:
Ipsilateral peribronchial
Ipsilateral hilar
Imaging features : N2

N2: ipsilateral mediastinal
Imaging features: N3

N3: contralateral mediastinal lymph nodes

Lt lung tumour with contralateral mediastinal lymph node
Imaging requirements

Immobilise on wingboard or vacloc
Spiral CT scans: 3-5mm slices from cricoid to L2

To address motion:

• Slow CT scans
• Breath hold CT scans
• 4 D CT scans
Window levels

Lung Window
Centre: -650
Width: 1500

Mediast Window
Centre: 40
Width: 400

Cortical bone
Spongy bone
Soft tissue
Water
Fat
Lung
Air
Determining GTV : CT

GTV: mediastinal window  
GTV: lung window
Issues in determining GTV:CT

• Challenges to radiotherapy planning:
  Atelectasis, effusion
  Inclusion of atelectasis: clinical decision

• Lung window, mediastinal window:
  Lung window for lung interface
  Soft tissue interface for mediastinal and hilar interfaces
  Bone window if infiltration suspected

• Lymphnodes remain difficult
MRI

T staging:

- Pancoast tumour
- Chest wall infiltration
- Tumour, effusion, atelectasis
- Mediastinal infiltration.
PET-CT

- Radiotherapy planning
- PET adds essential information to CT
- Lymph node involvement
- Differentiation tumor vs atelectasis
- Drawback: inflammatory disease
- Recommended for all dose escalation studies
Defining CTV in lung cancer

• Microscopic disease
**Microscopic disease**

Good correlation between radiologic and pathologic tumour size.

Microscopic tumour extension: 6mm (squamous cell), 8mm (adenocarcinoma).

Giraud et al., IJROBP, 2000: 48§1015
Other important issues

• Organs at risk:
  • Lung
  • Esophagus
  • Spinal cord

• Issues unaddressed
  • PTV margins for motion (most imp for lung)
  • Tumour regression patterns
Nodal target volume in lung cancer
Nodal stations of thorax

- **1R**: highest mediastinal nodes
- **2R, 2L**: upper paratracheal nodes
- **3A**: prevascular nodes and retrotracheal nodes
- **4**: right, left lower paratracheal nodes
- **5**: subaortic (aortic–pulmonary window)
- **6**: paraaortic nodes
- **7**: subcarinal nodes
- **8**: paraesophageal nodes
- **10**: hilar nodes
- **11**: interlobar nodes
Level 1-3

Chapet, IJROBP, 2005: 63; 170
Level 3, 4, 6
Level 4-8
Level 10-11R
Level 10-11L
Patterns of lymphatic drainage of lungs
Patterns of lymphatic drainage of lungs

Kotoulas, Lung Cancer, 2004:44;183
Lymphatic drainage according to tumour site

<table>
<thead>
<tr>
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<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8,9</th>
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Skip mets to mediastinum > in upper lobe tumours (40% vs 20% in LL) 
Skip mets more common in adenoca

Basis for delineating hilum in T4 and N2 cases!
Evaluation of the mediastinum

- CT

- **Mediastinoscopy**: station 1, 2, 4 and 7 lymph nodes

- **EBUS-TBNA**: endobronchial UG guided transbronchial needle aspiration: subcarinal LN

- **EUS-FNA**: esophageal ultrasound guided fine needle aspiration station 8, 9, 7, and 5 lymph nodes

- PET
## Proposal for defining mediastinal GTV

<table>
<thead>
<tr>
<th>Nodal diameter and PET</th>
<th>Action</th>
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<tbody>
<tr>
<td>&lt; 1cm PET +ve</td>
<td>Include in GTV</td>
</tr>
<tr>
<td>&lt;1cm PET -ve</td>
<td>Exclude from GTV</td>
</tr>
<tr>
<td>&gt;1cm PET +ve</td>
<td>Include in GTV unless cyto -ve</td>
</tr>
<tr>
<td>&gt;1cm PET -ve</td>
<td>Include in GTV if primary PET -ve \nIF primary PET +ve exclude from GTV</td>
</tr>
<tr>
<td>&gt; 1cm or conglomerate of LN on CT</td>
<td>Include in GTV</td>
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Senan et al R&O, 2004
ENI vs INI
Types of nodal irradiation

- **ENI**
  - False negative rate on CT scan
  - Occult micrometastases
  - Higher toxicity
  - Pneumonitis: 17% vs 29%
  - Limitation of dose escalation
  - 2% ENF

- **Involved field**
  - Higher local control
  - HR death decreases
  - (2–3% per Gy BED)
  - Less toxicity
  - Higher doses
  - 6% ENF
Prospective data (ENI vs INI)

- 200 patients
- ENI 60-64 Gy vs Involved field 68-74 Gy
- ORR: 79% vs 90% (p = 0.032)
- Rate of elective nodal failure 7%
- 5 yr LCR: 36% vs 51% (p = 0.032)
- 3 yr survival 20% vs 27%
- Pneumonitis rate 39% vs 17%

Yuan et al, AmJ Clin Oncol, 2007:30,239
CTV for nodal disease

Extranodal spread:
<2mm:3mm
>3mm:8mm

An average of 5mm is sufficient.
Recommendations

Based on CT scan:

CT scan GTV primary + LN more than 1 cm, conglomerate of lymph nodes

T4,N2: include hilum
If abnormal hilum: entire hilum
If normal hilum: upper pole for UL
lower pole for LL

Based on PET scan:
FDG PET positive tumours > SUV 3
CTV postoperative case
Patterns of failure after surgery

- Postop pts,c/m negative, no adjuvant RT or CT
- All SCF rec assoc with upper med inv
- All C/L rec assoc with ipsilateral relapses

Kelsey et al 2006:65:1097
Patterns of failure after surgery
## Radiotherapy target volumes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Stage</th>
<th>Target volume</th>
<th>Total dose</th>
<th>Local failure S vs S+RT</th>
<th>Survival S vs S+RT</th>
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<tbody>
<tr>
<td>Van Houtte et al 224</td>
<td>N0</td>
<td>Bronchial stump, ipsilateral hilum, mediastinum</td>
<td>60</td>
<td>19% vs 4%</td>
<td>43% vs 24% (5yr)</td>
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<tr>
<td>Dautzeberg et al 728</td>
<td>I-III</td>
<td>Bronchial stump, ipsilateral hilum, mediastinum</td>
<td>60</td>
<td>34% vs 28% (5yr)</td>
<td>43% vs 30% (5yr)</td>
</tr>
<tr>
<td>Mayer et al 155</td>
<td>T1-3 N0-2</td>
<td>Bronchial stump, ipsilateral hilum, mediastinum</td>
<td>50-56</td>
<td>24% vs 6%</td>
<td>20% vs 30% (5yr)</td>
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<tr>
<td>Trodella 104</td>
<td>T1-2, N0</td>
<td>Bronchial stump, ipsilateral hilum</td>
<td>50.4</td>
<td>23% vs 2%</td>
<td>58% vs 67% (5yr)</td>
</tr>
</tbody>
</table>
Take home message

• CTV lung tumour: CT volume with 5mm margin

• CTV nodes: CT nodes > 1cm, conglomerate of nodes in any station with 5 mm margin

• CTV postoperative case: bronchial stump, ipsilateral hilum mediastinum in N2 cases