# Target volume delineation in lung cancers

Sushma Agrawal
Department of Radiotherapy
SGPGIMS, Lucknow

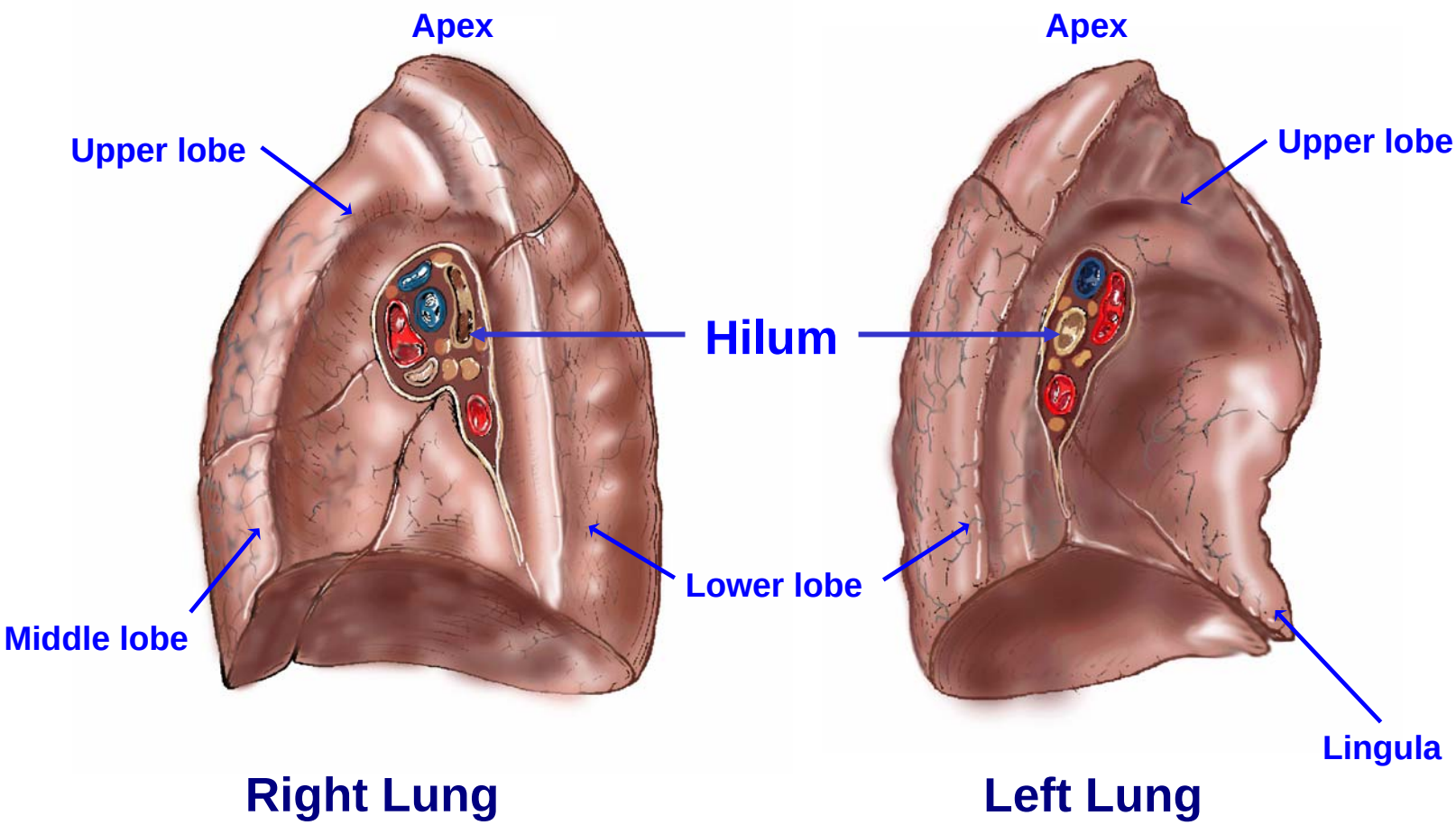
# Road map

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

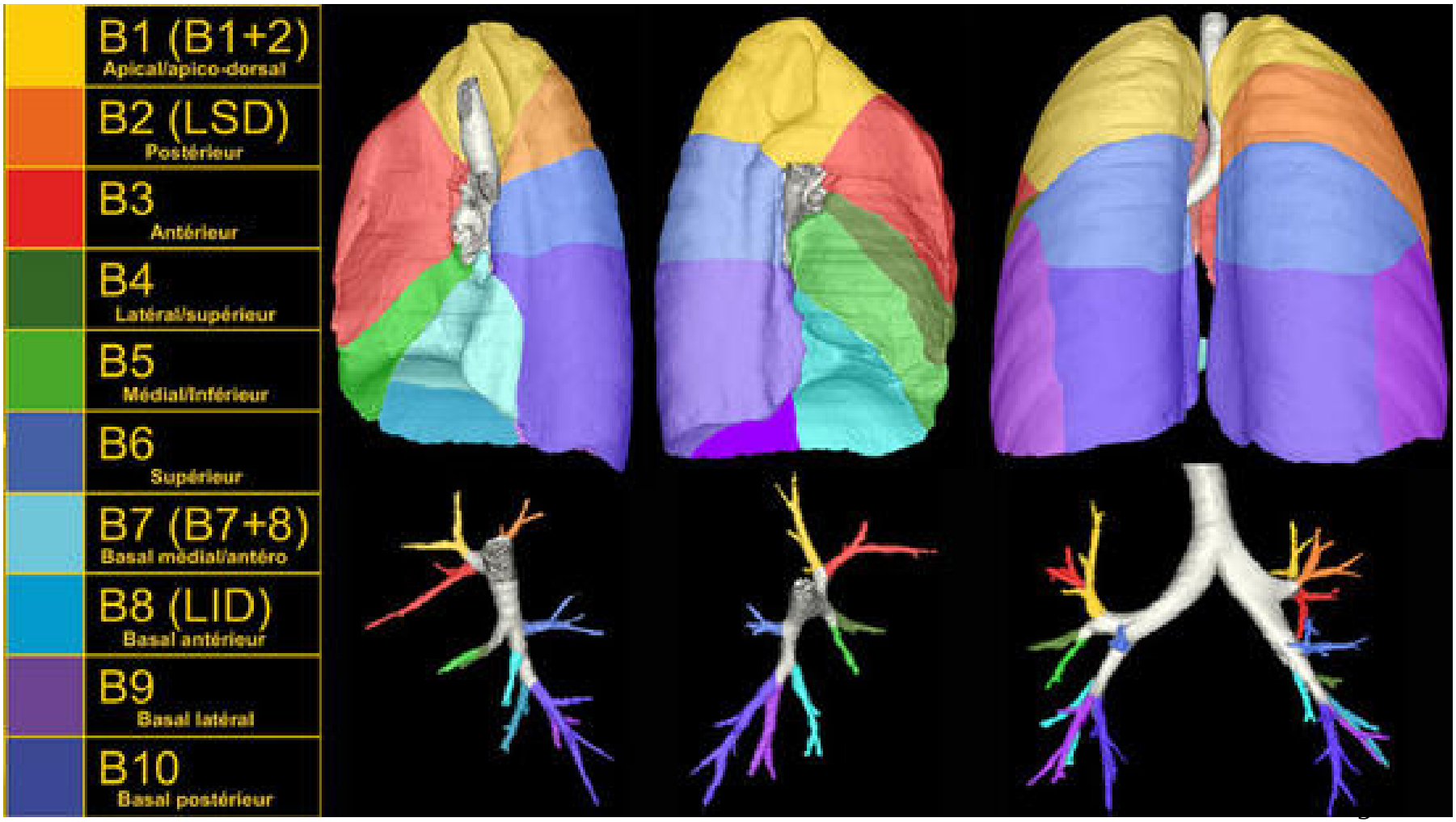
# GTV lung tumour

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

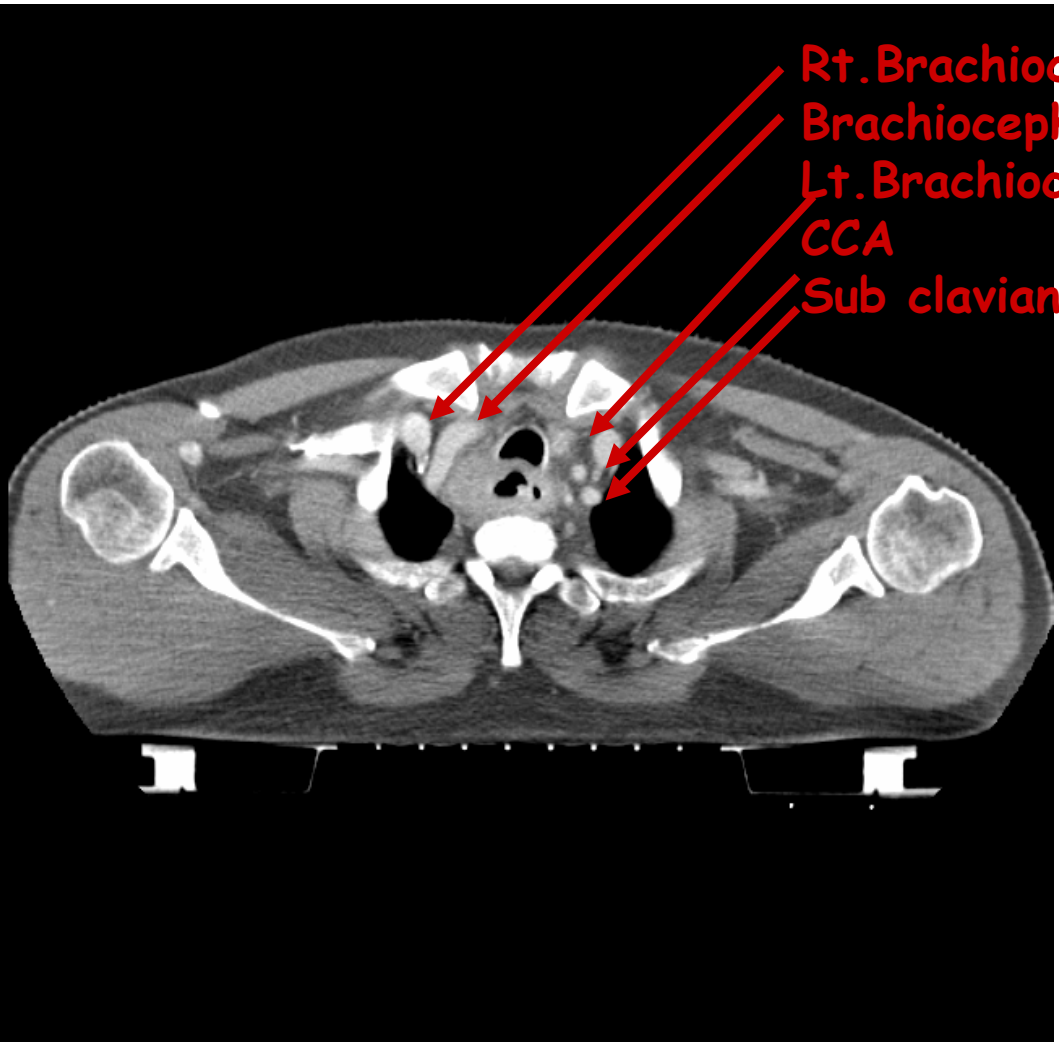
# Anatomy of lungs

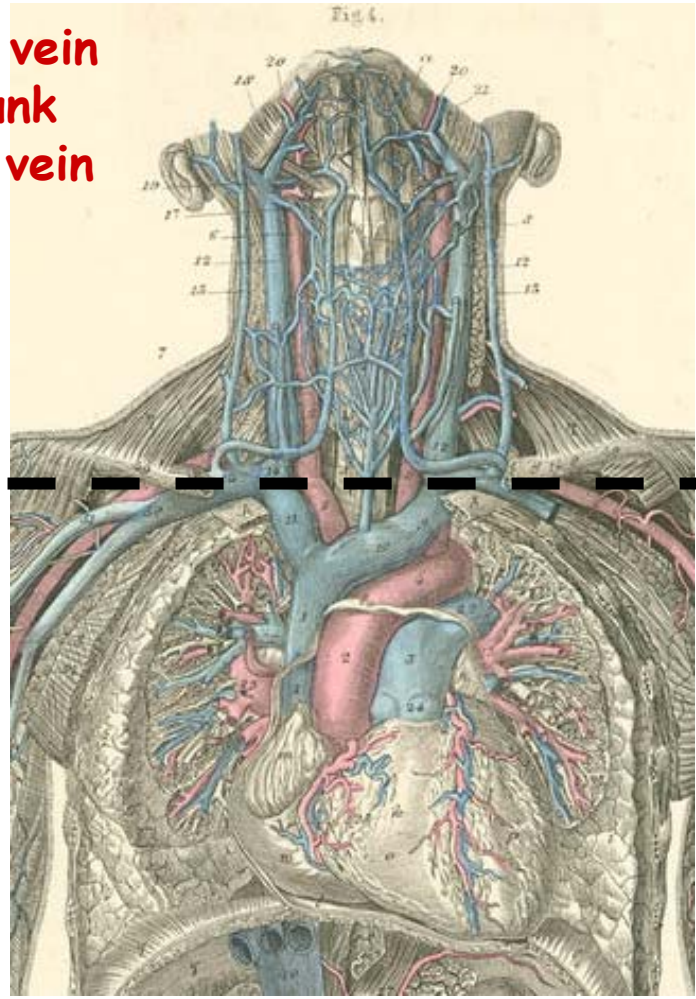


# Bronchopulmonary segments

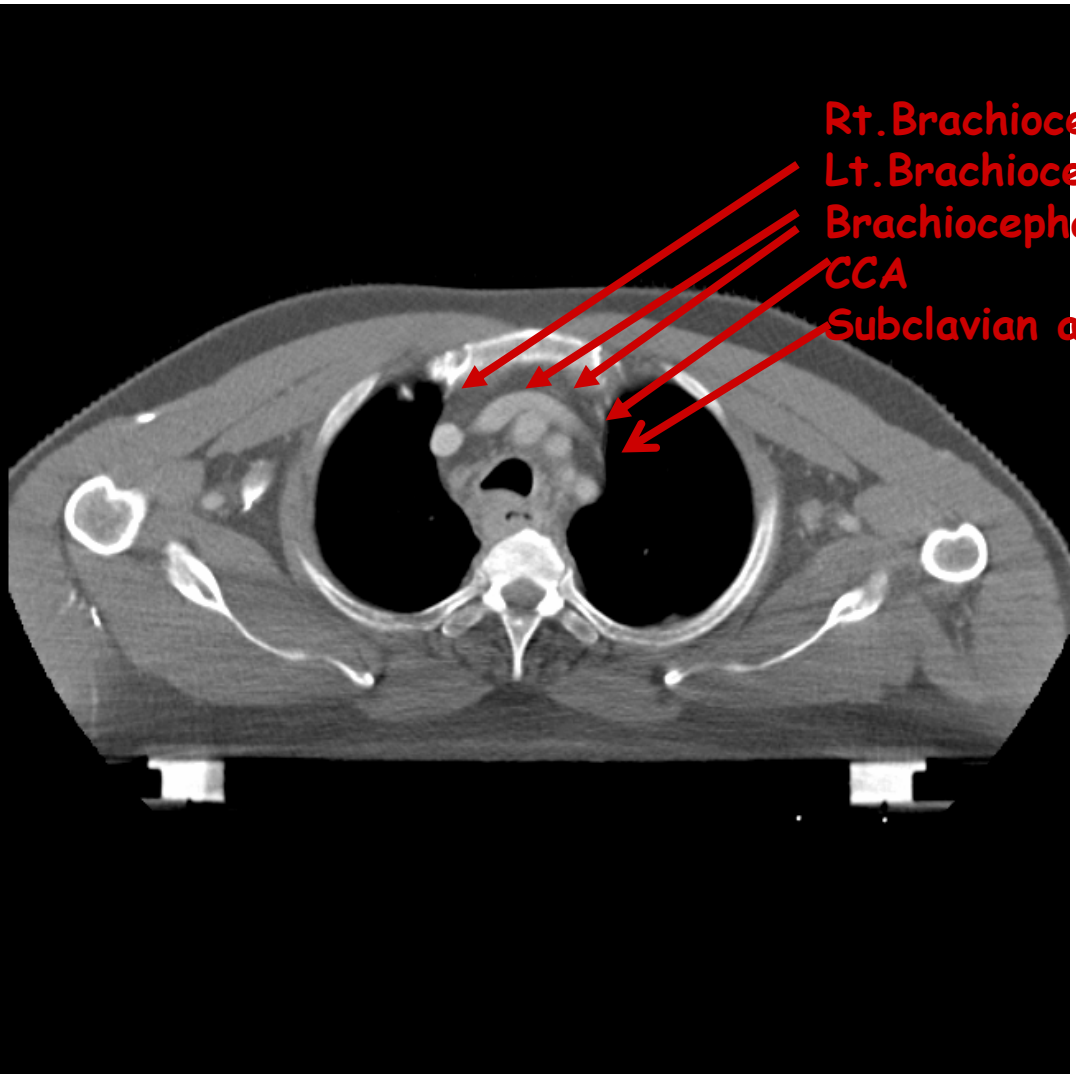


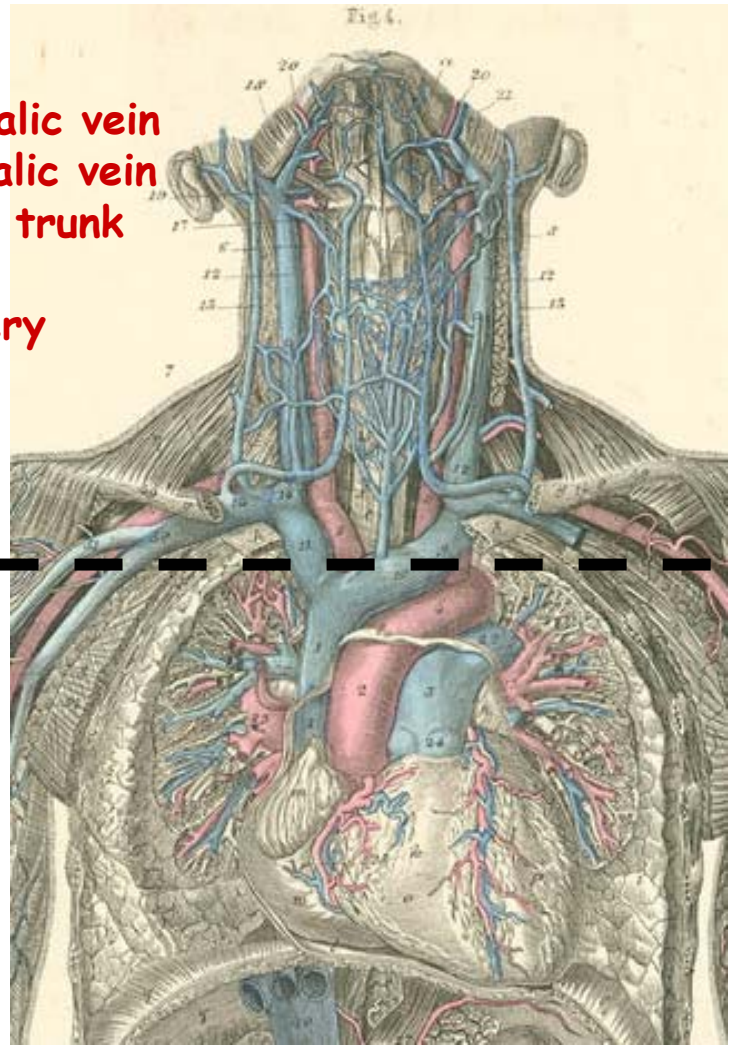
# Anatomy of thorax supraaortic level I



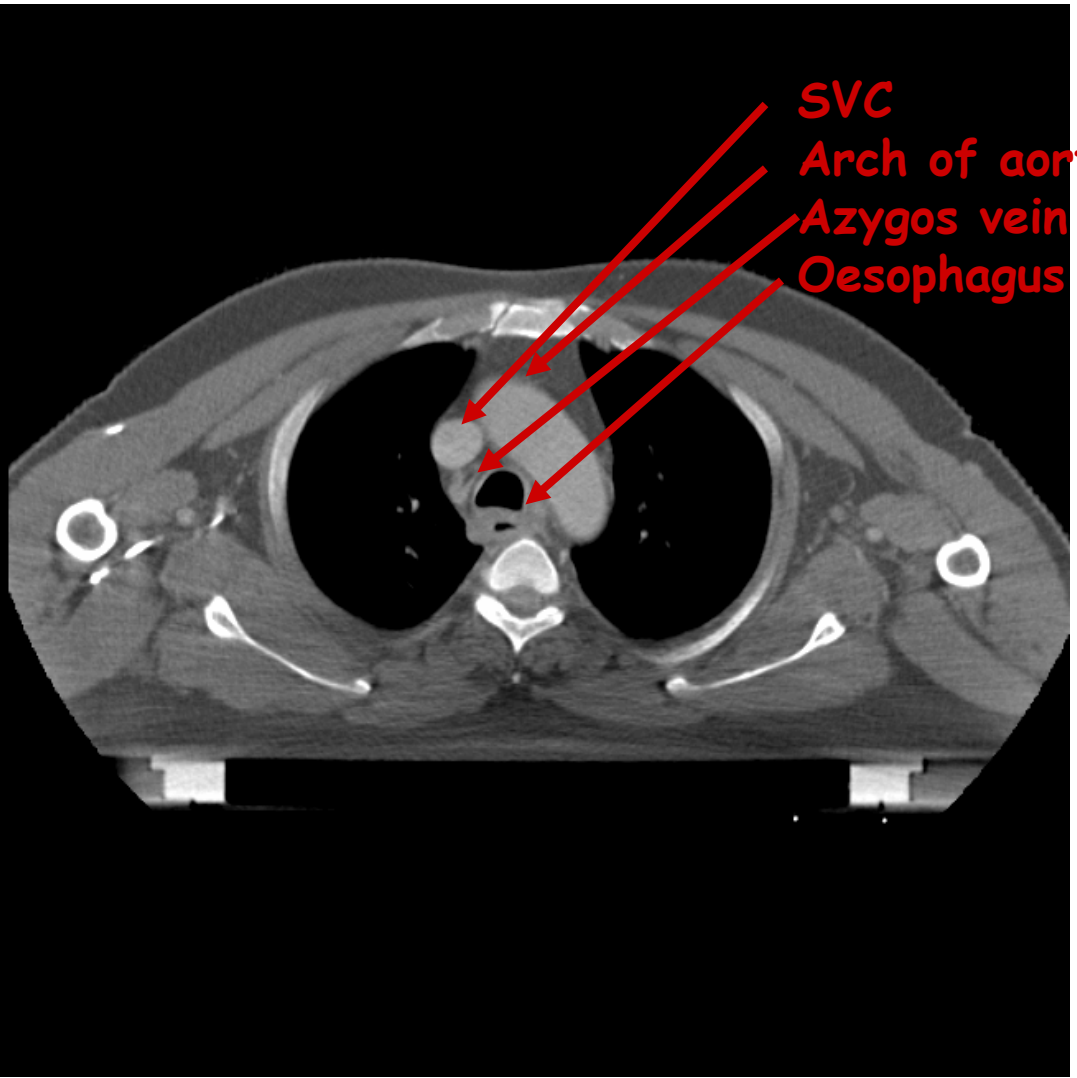



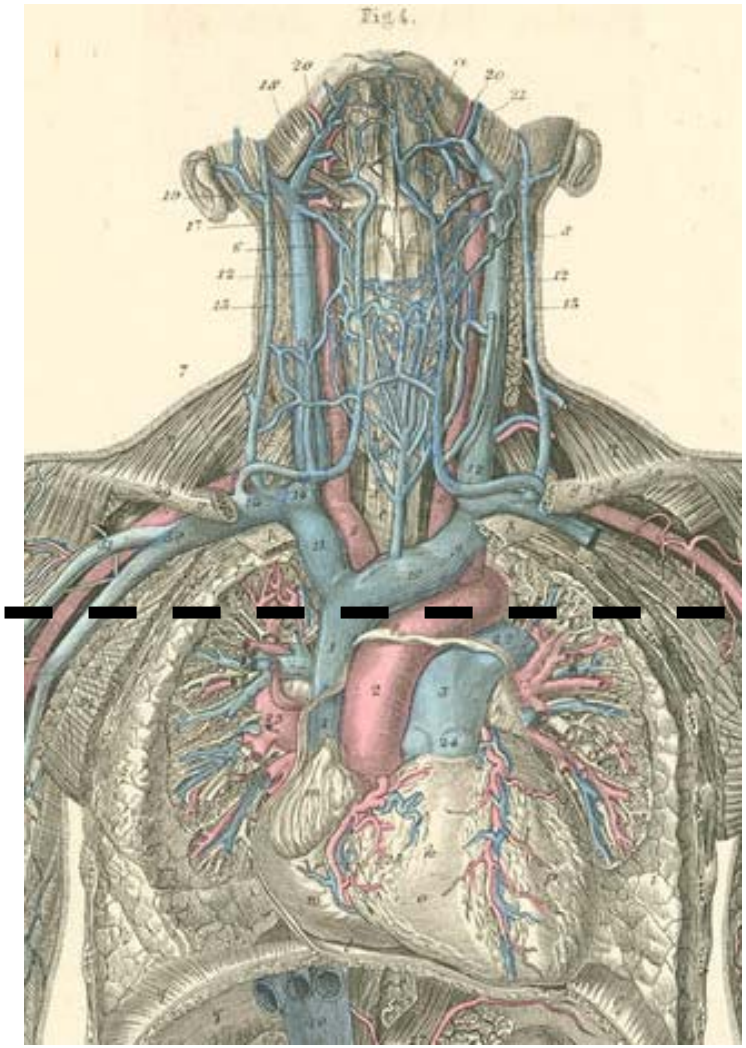
# Supraaortic level II



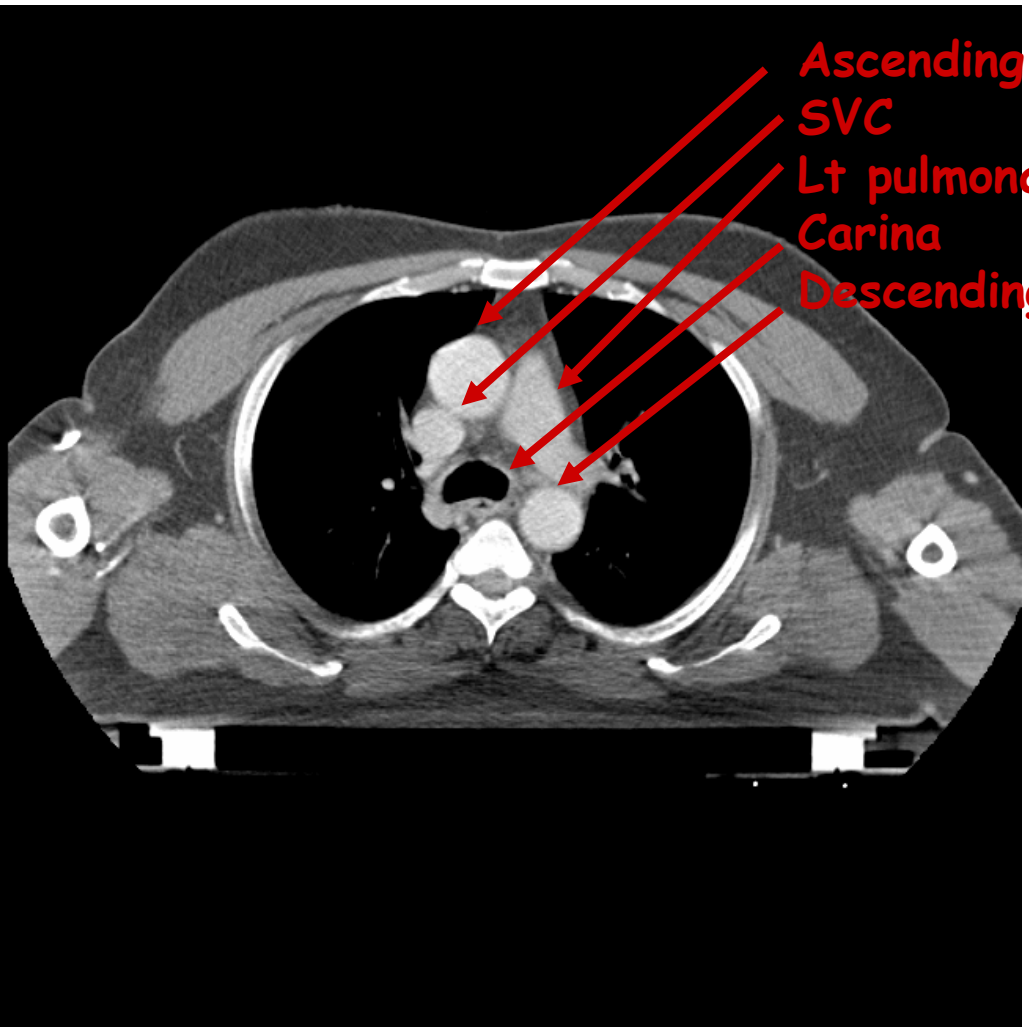



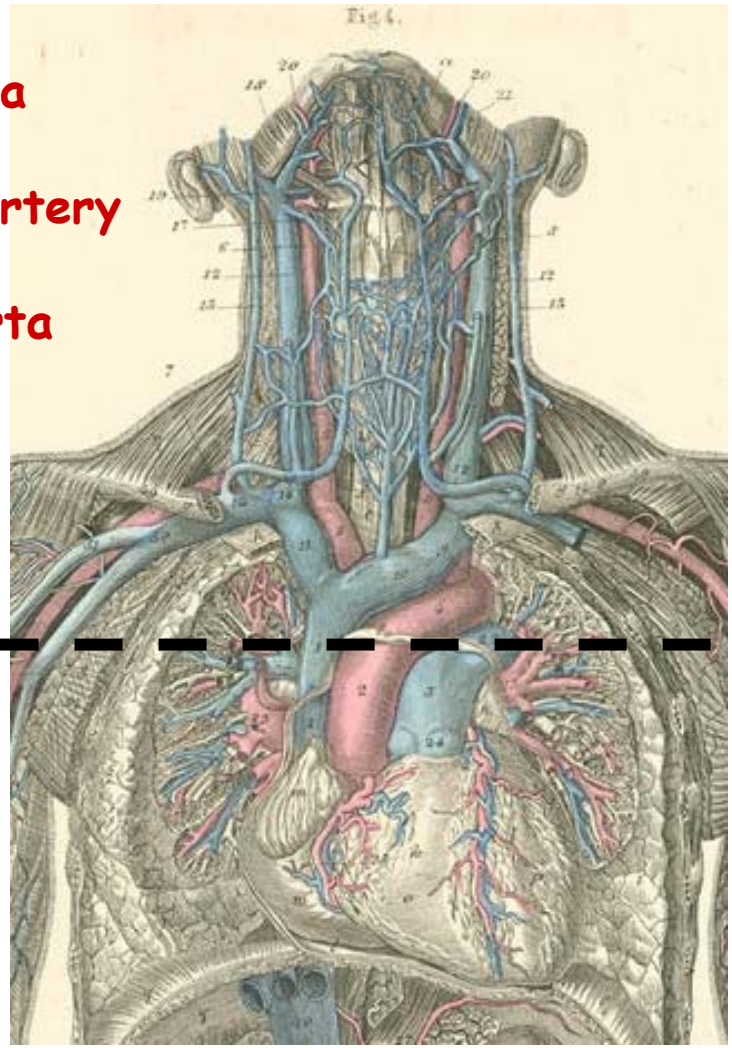
# Aortic arch



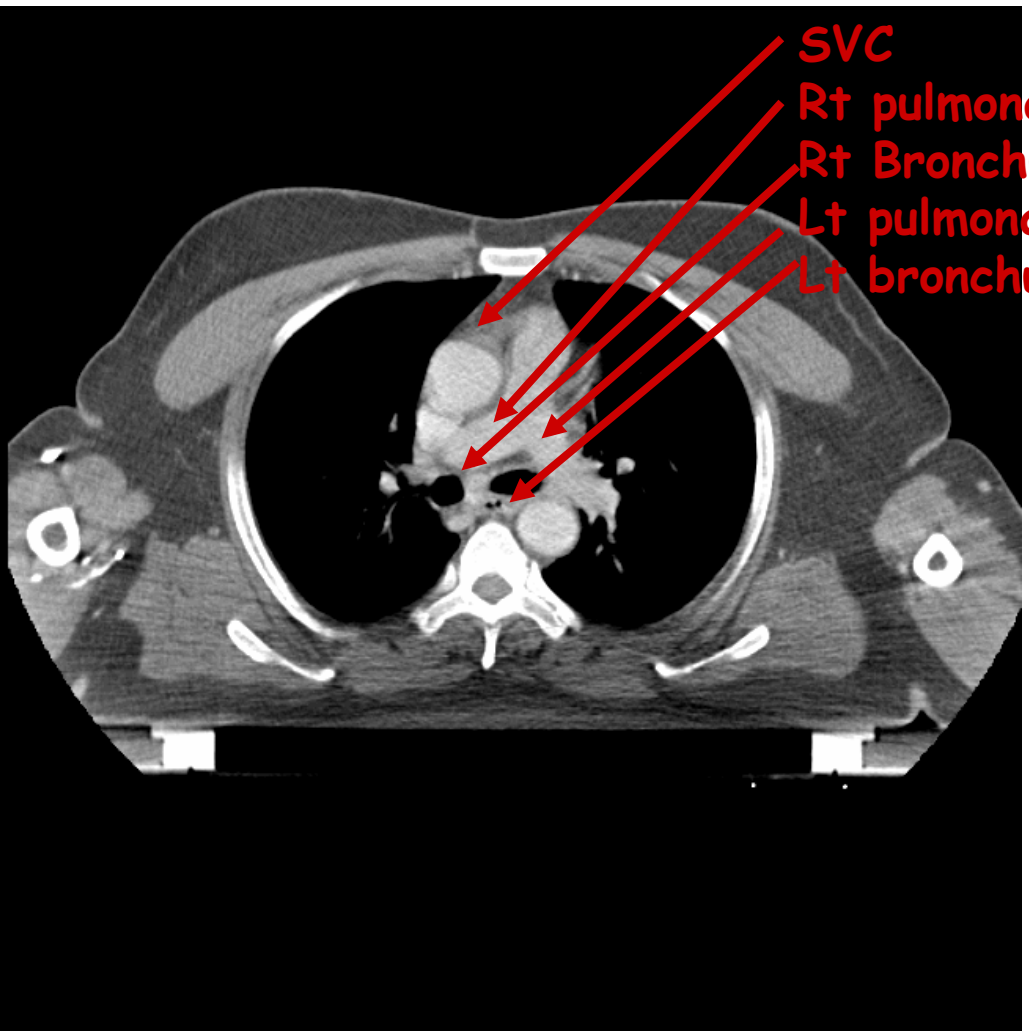



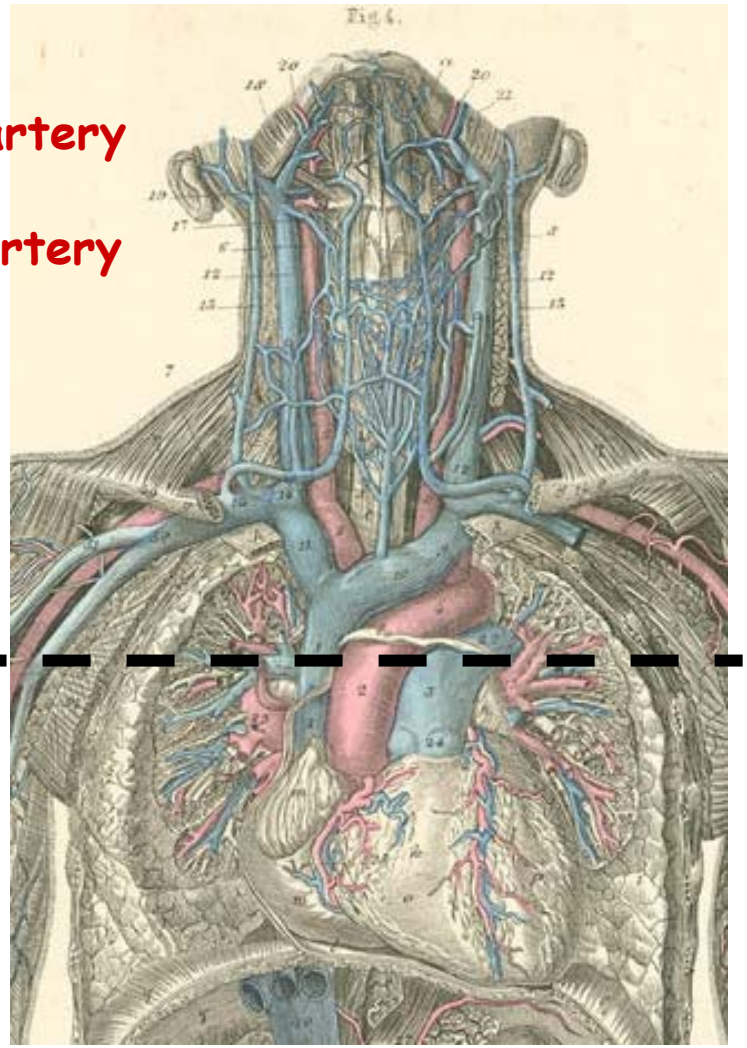
# Left pulmonary artery and carina



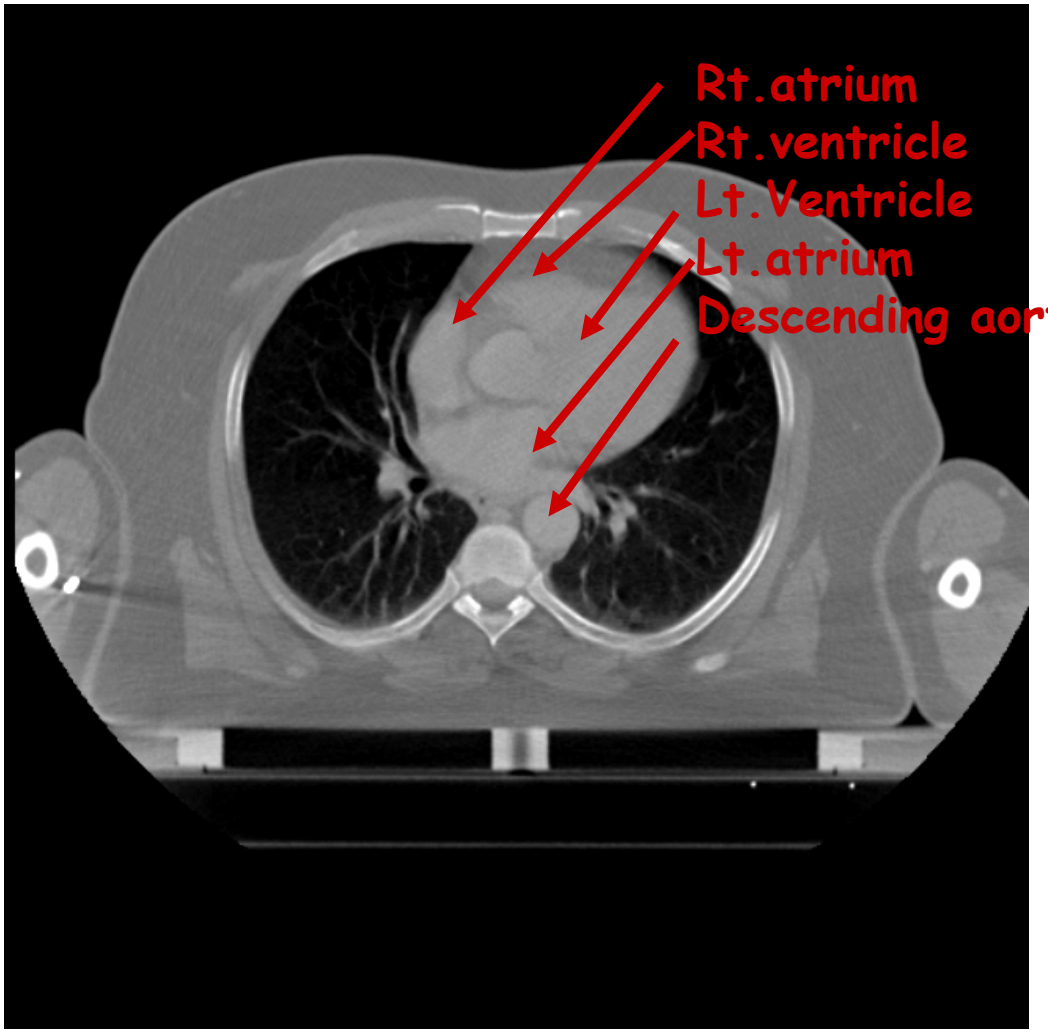



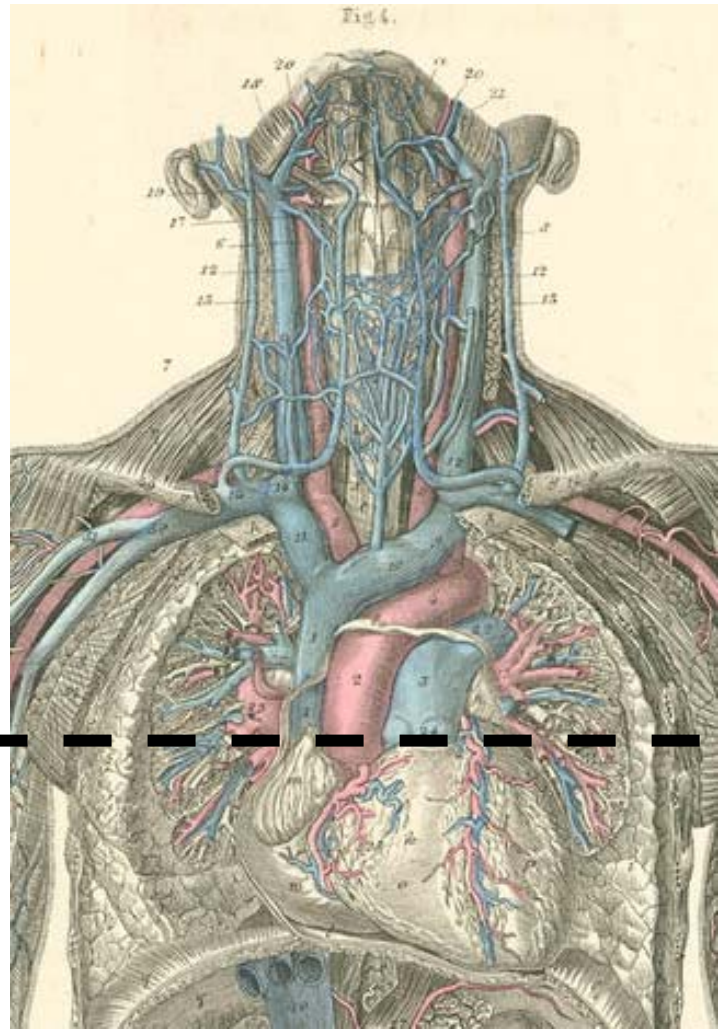
# Right pulmonary artery



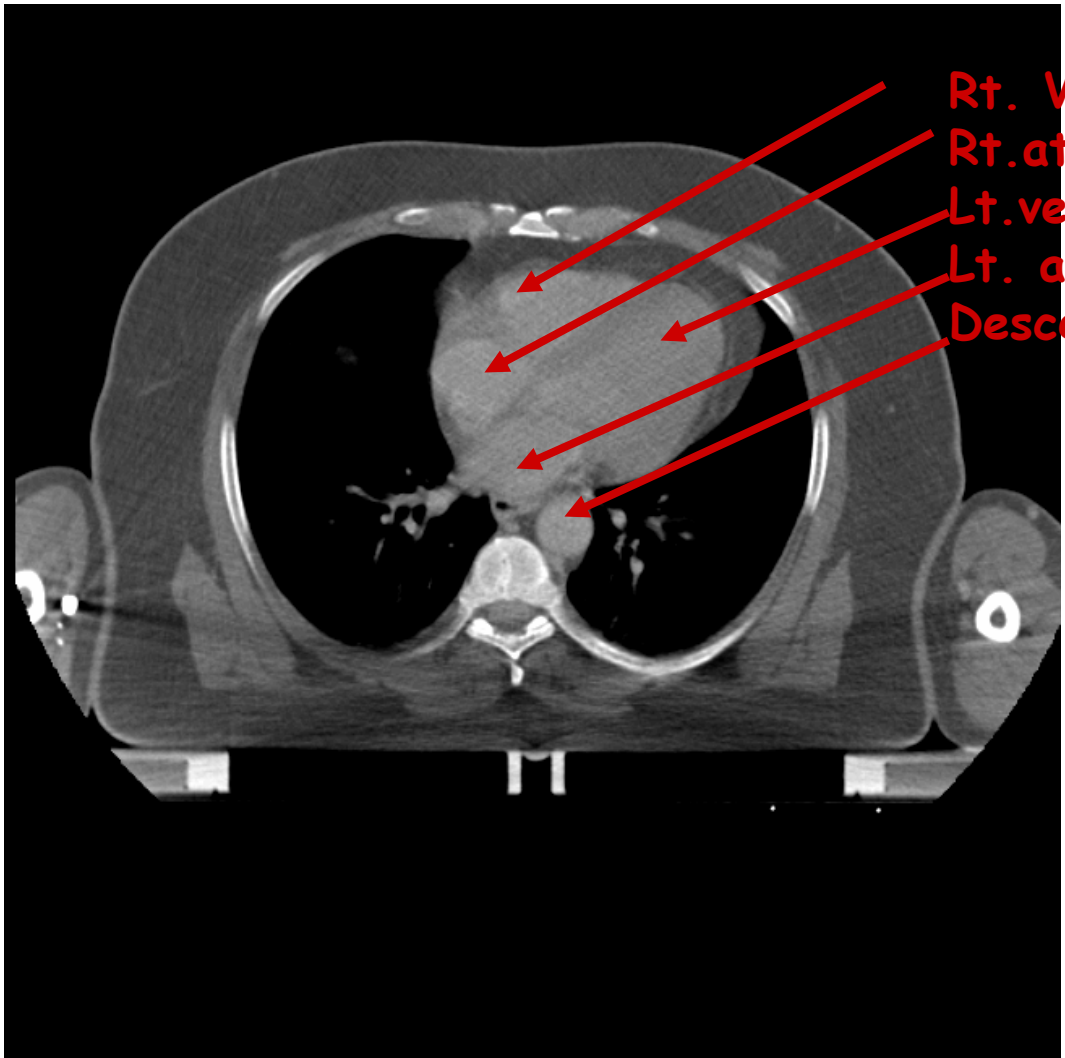



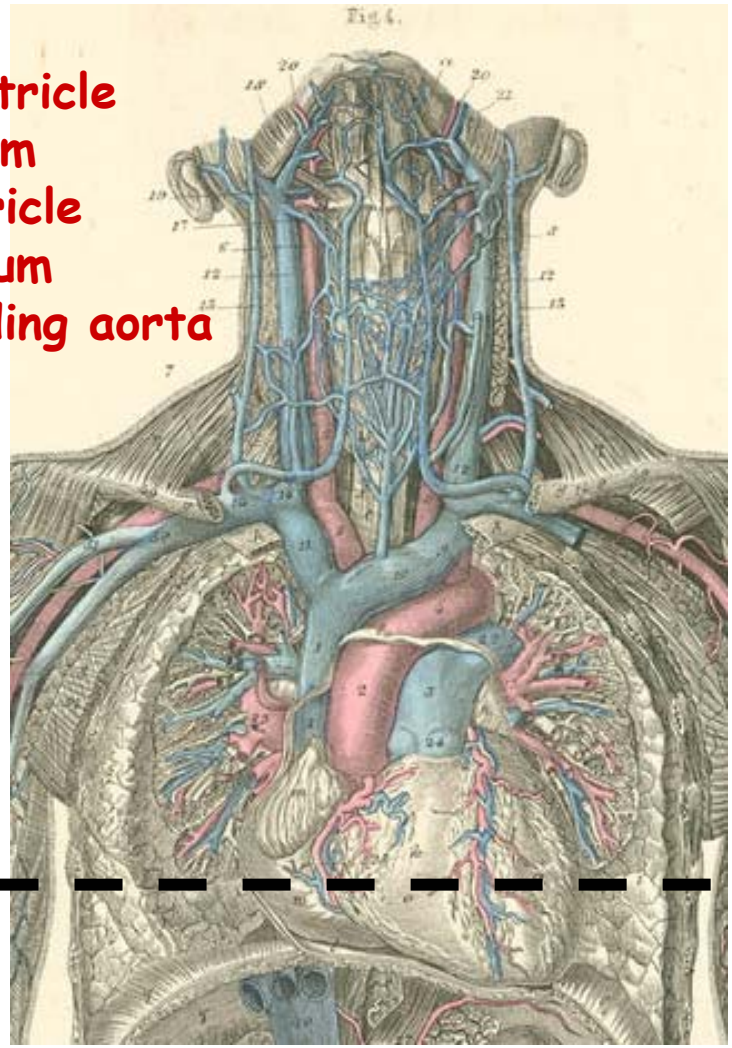
# Left atrium


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

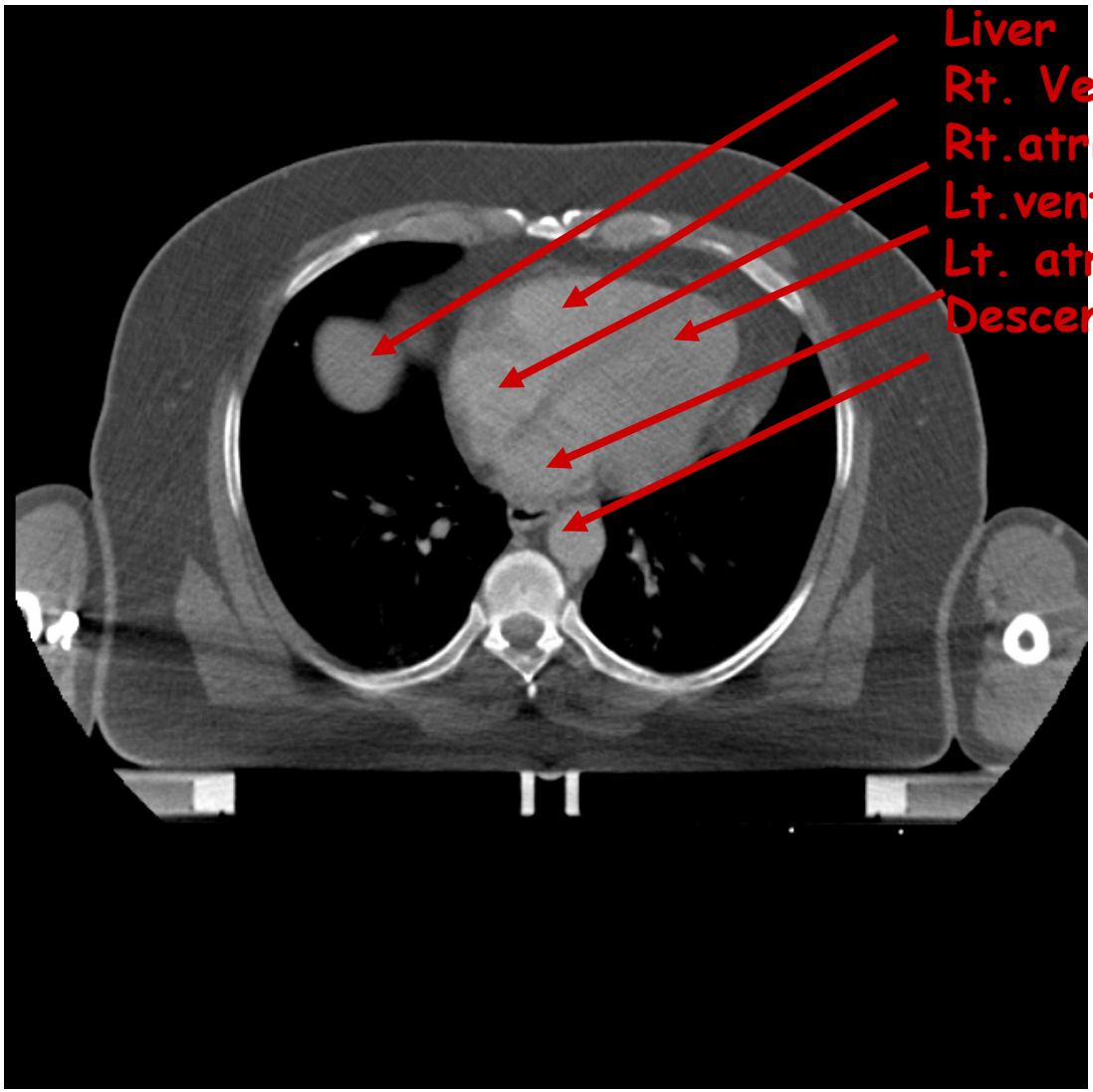


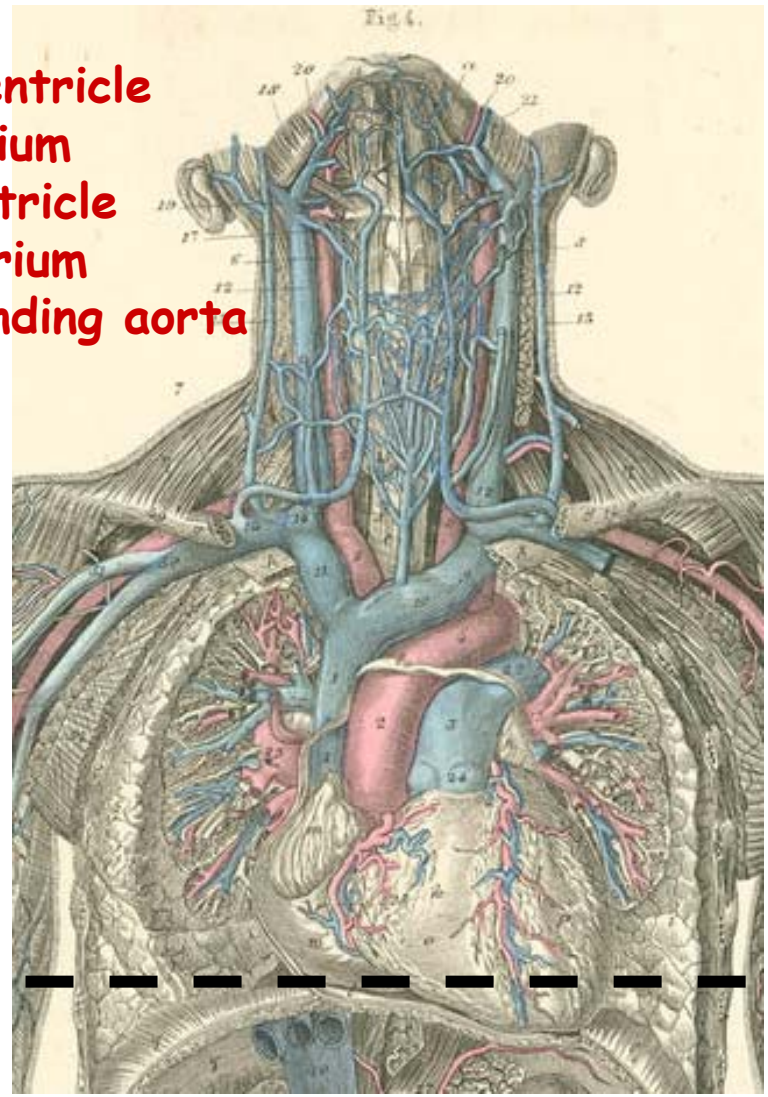
# Left ventricle



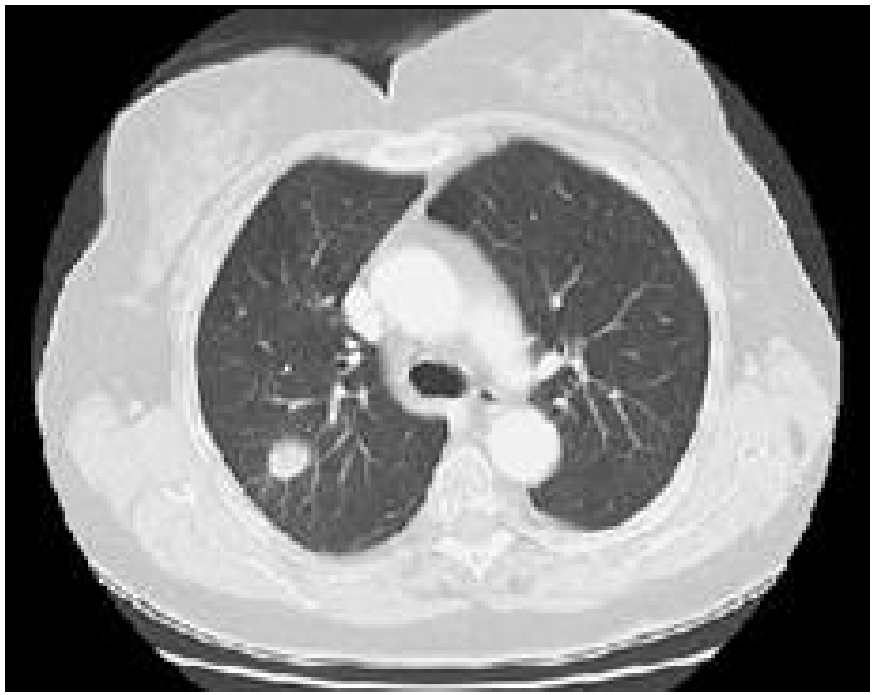
# Supradiaphragmatic level

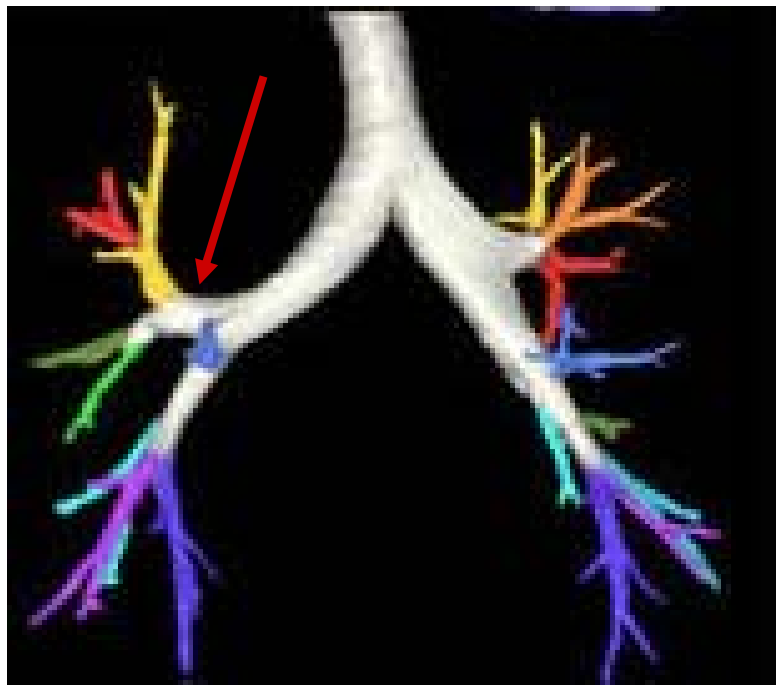


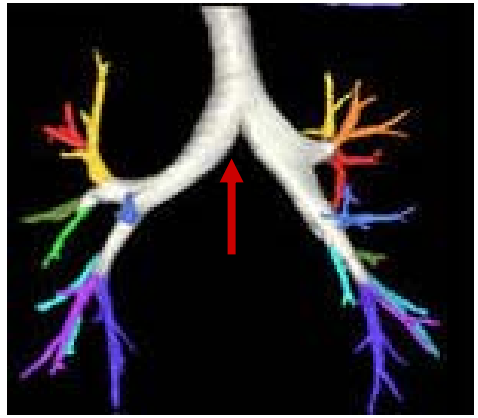
# Imaging features:T1

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

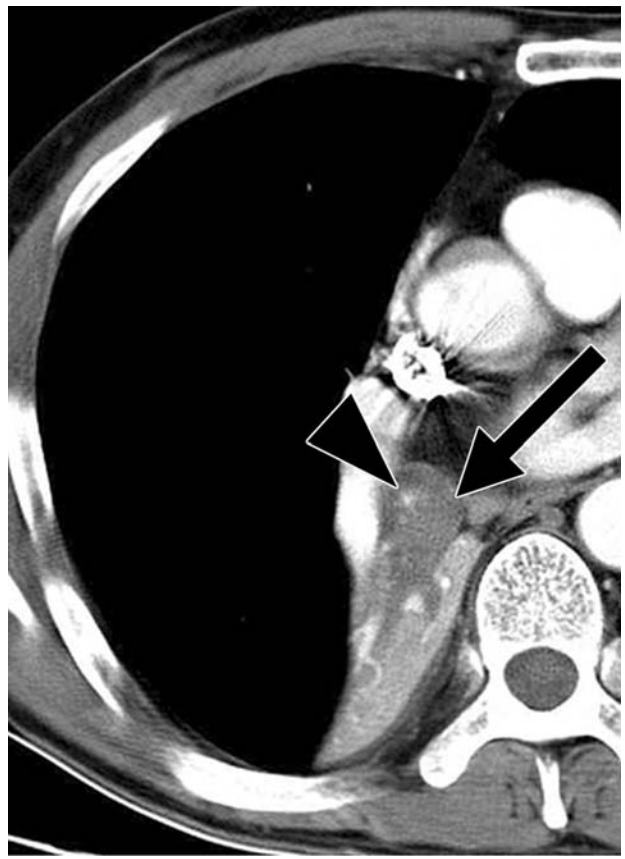




# Imaging features :T2



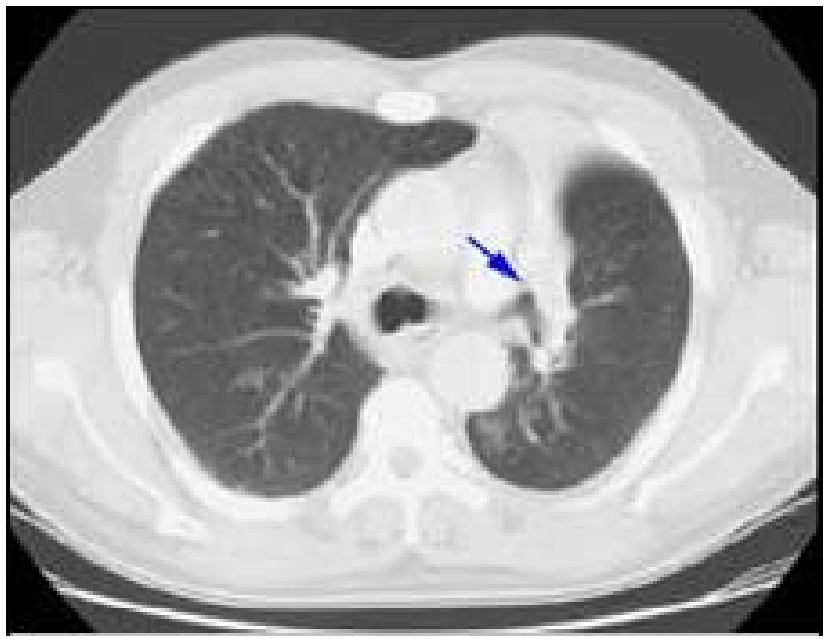
T2: Tumor > 3 cm,
main bronchus > 2 cm from carina
Visceral pleura invasion
Atelectasis,consolidation not inv entire lung



# 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 superior segment LL lobe with a satellite nodule in ipsilateral tumor lobe

Mass obstr left UL bronchus & UL collapse,and pleural effusion

# Imaging features:N1

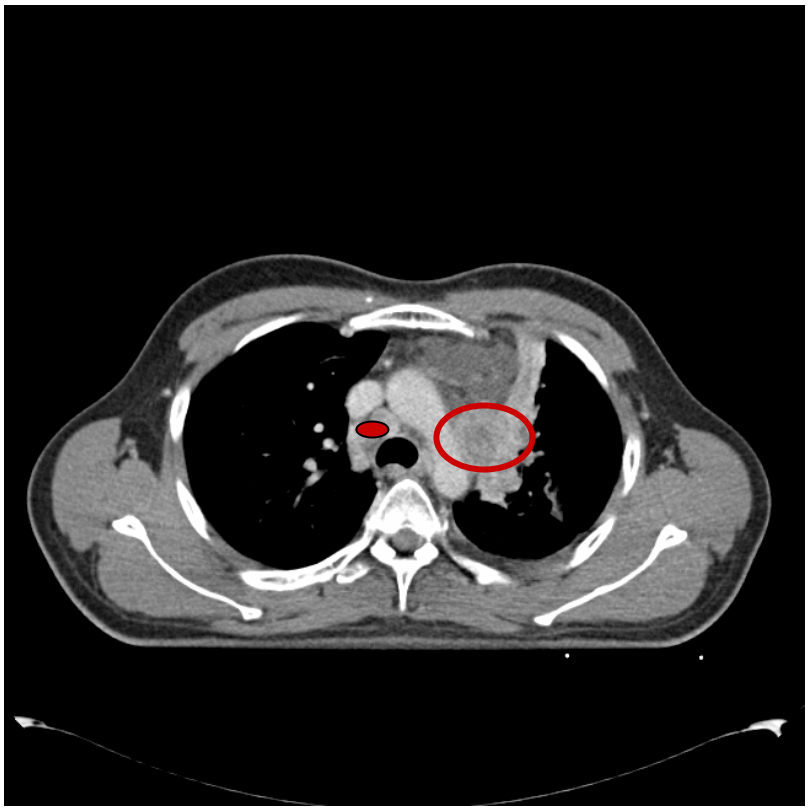
**N1:**
Ipsilateral peribronchial
Ipsilateral hilar

# Imaging features :N2

N2:ipsilateral mediastinal

# Imaging features:N3

## N3:contralateral mediastinal lymph nodes



Lt lung tumour with contralateral mediastinal lymphnode

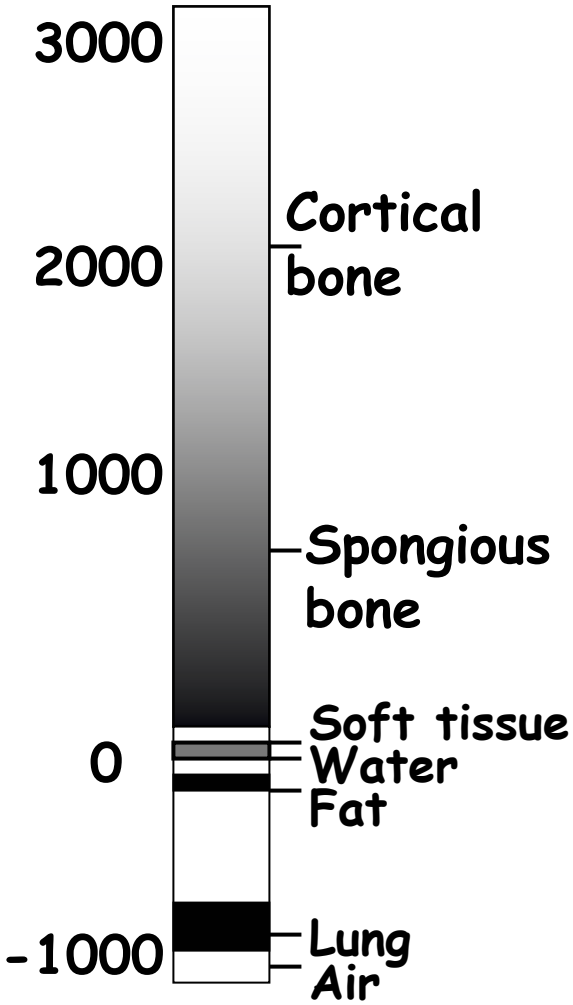
# Imaging requirements

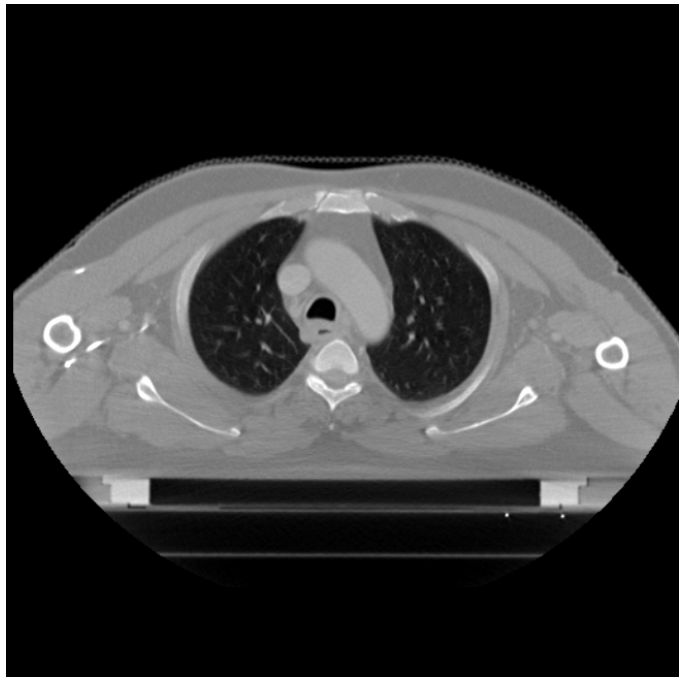
Immobilise on wingboard or vacloc
Spiral CT scans:3-5mm slices from cricoid to L2

To address motion:

- Slow CT scans
- Breath hold CT scans
- 4 D CT scans

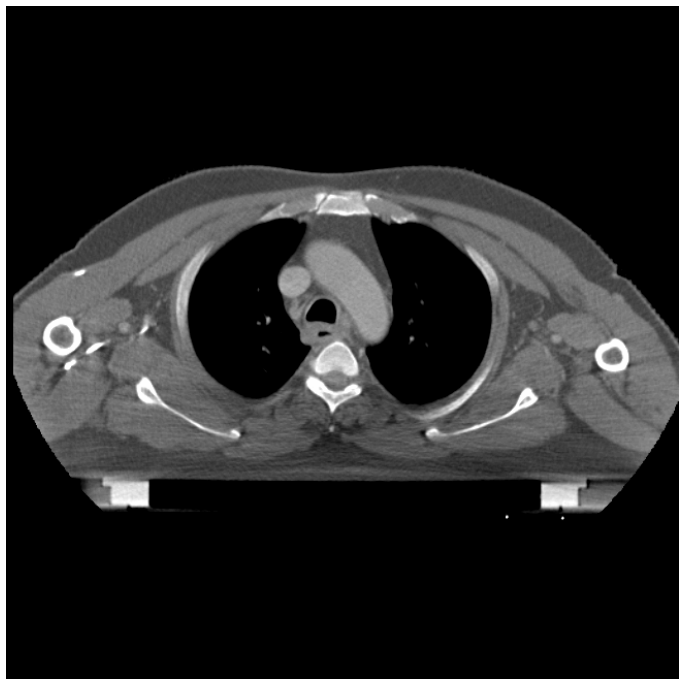
# Window levels



Lung Window

Centre:-650
Width:1500

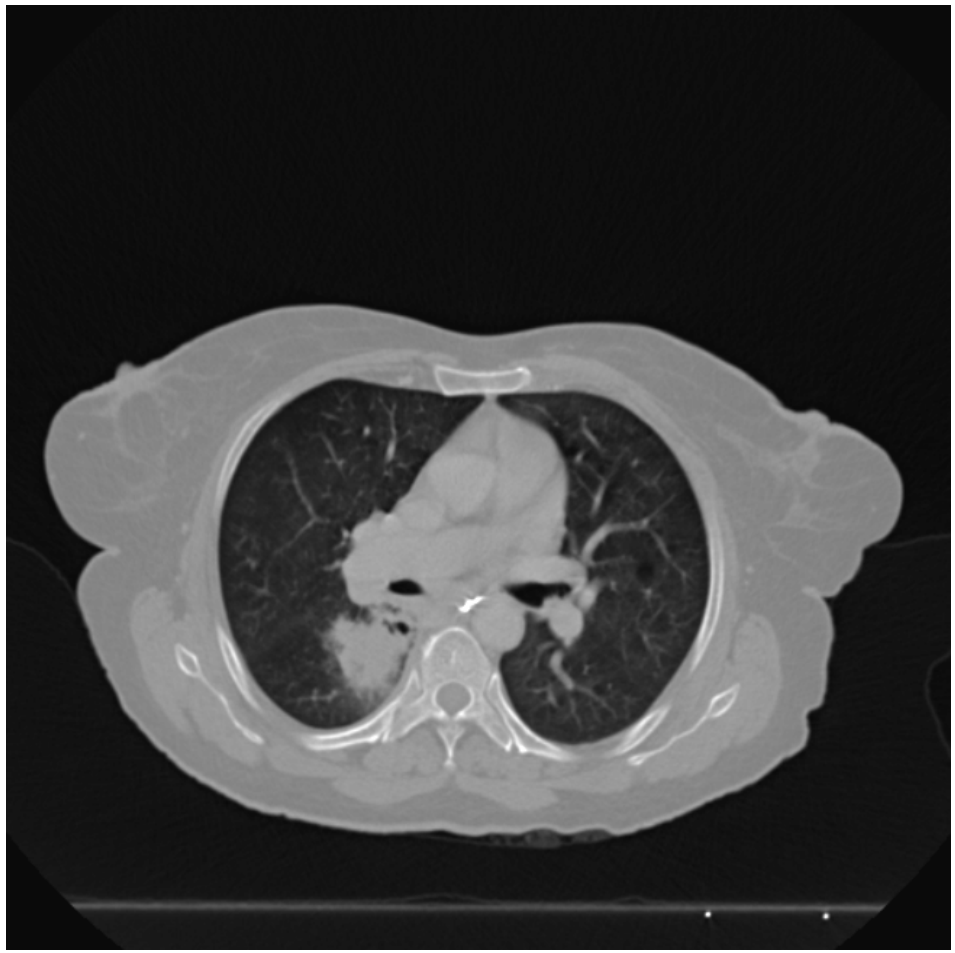


Mediast Window

Centre:40
Width:400

# 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**

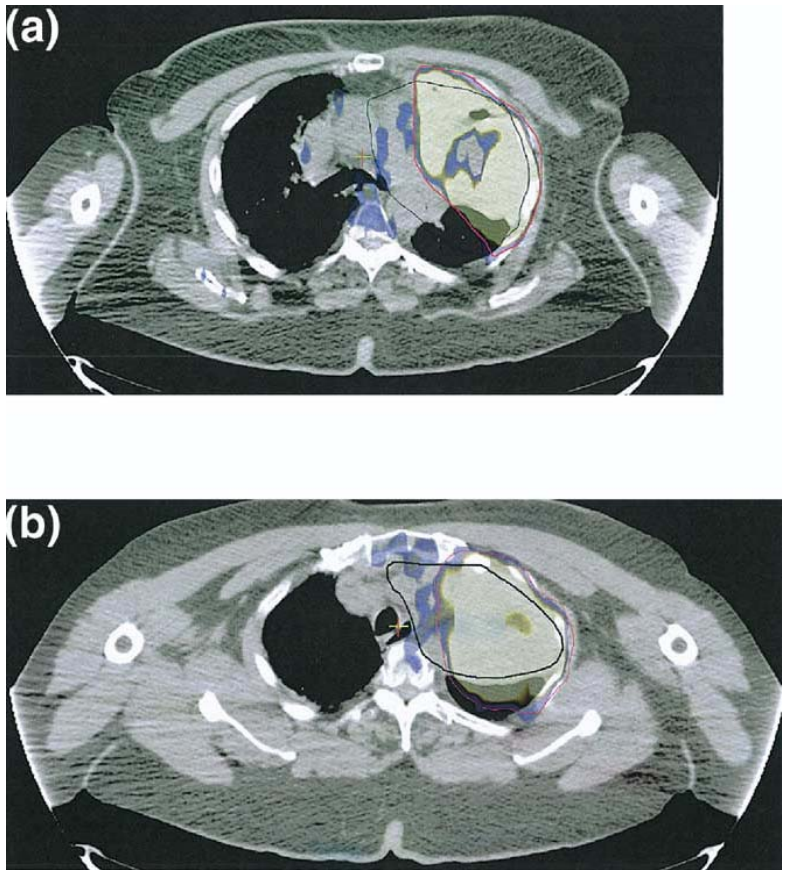
# MRI

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

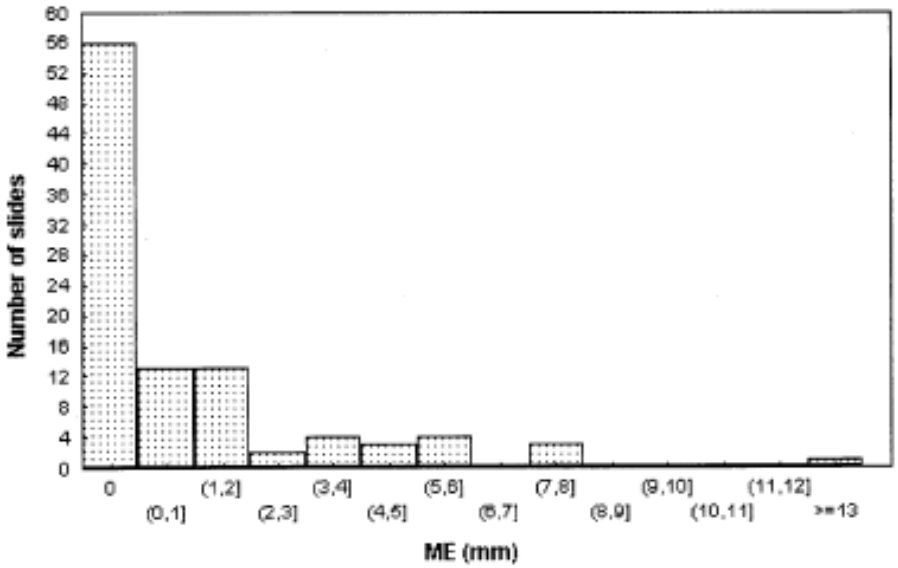


# Defining CTV in lung cancer

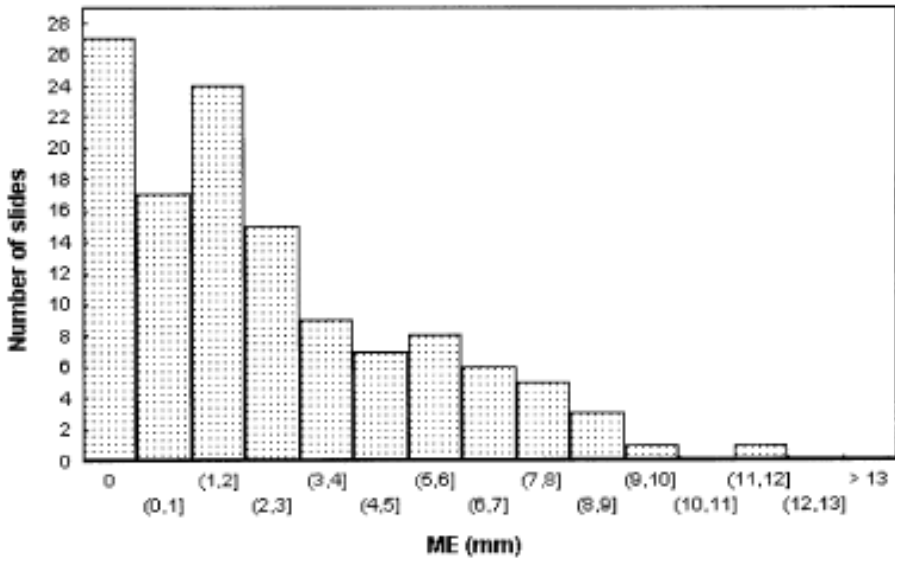
- Microscopic disease

# Microscopic disease

Good correlation between radiologic and pathologic tumour siz
Microscopic tumour extension:6mm(squamous cell),
8mm (adenocarcinoma)




Microscopic extension in SCC




Microscopic extension in Adenoca

Giraud et al,IJROBP,2000:48:1015

# Other important issues

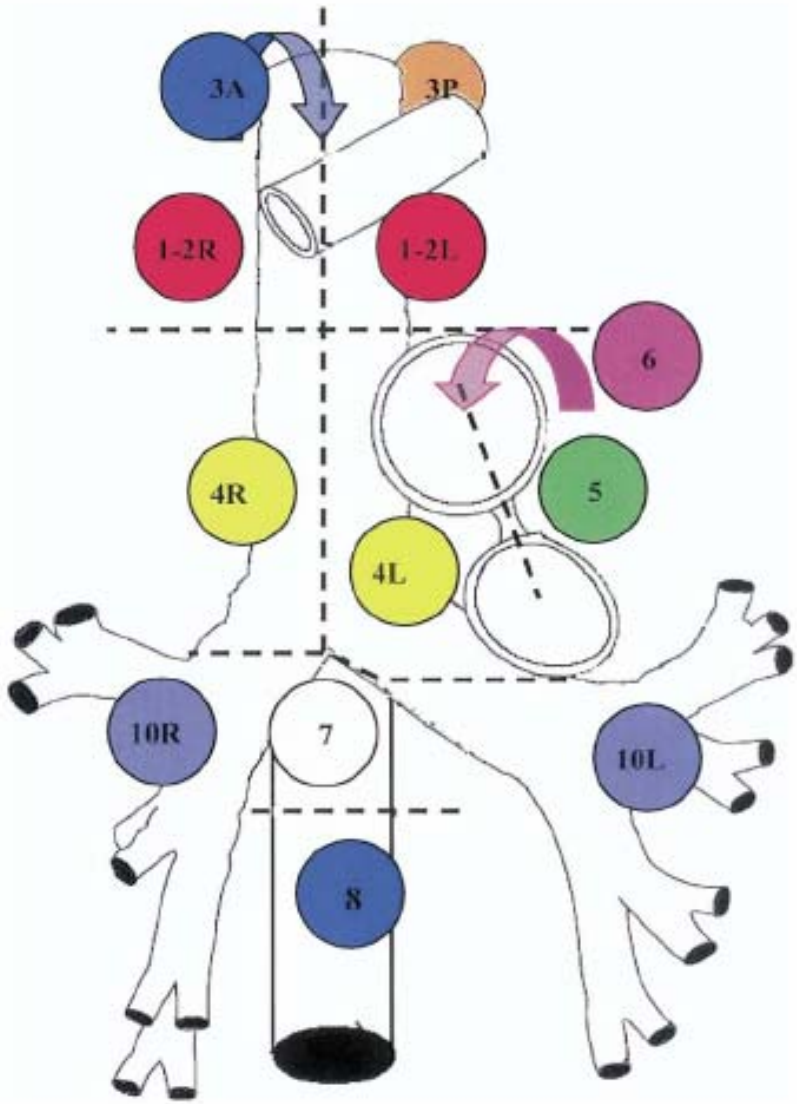
- **Organs at risk:**
- Lung
- Esophagus
- Spinal cord

- **Issues unaddressed**
- PTV margins for motion (most imp for lung)
- Tumour regression patterns

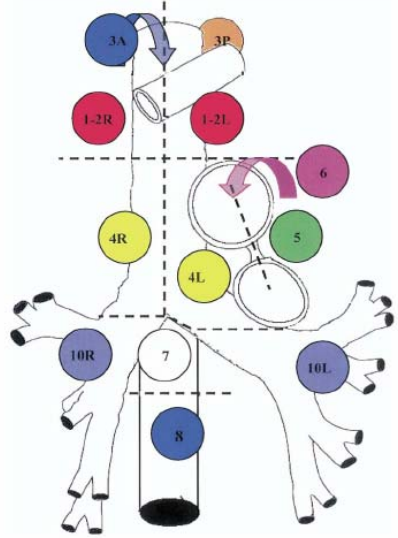
# Nodal target volume in lung cancer

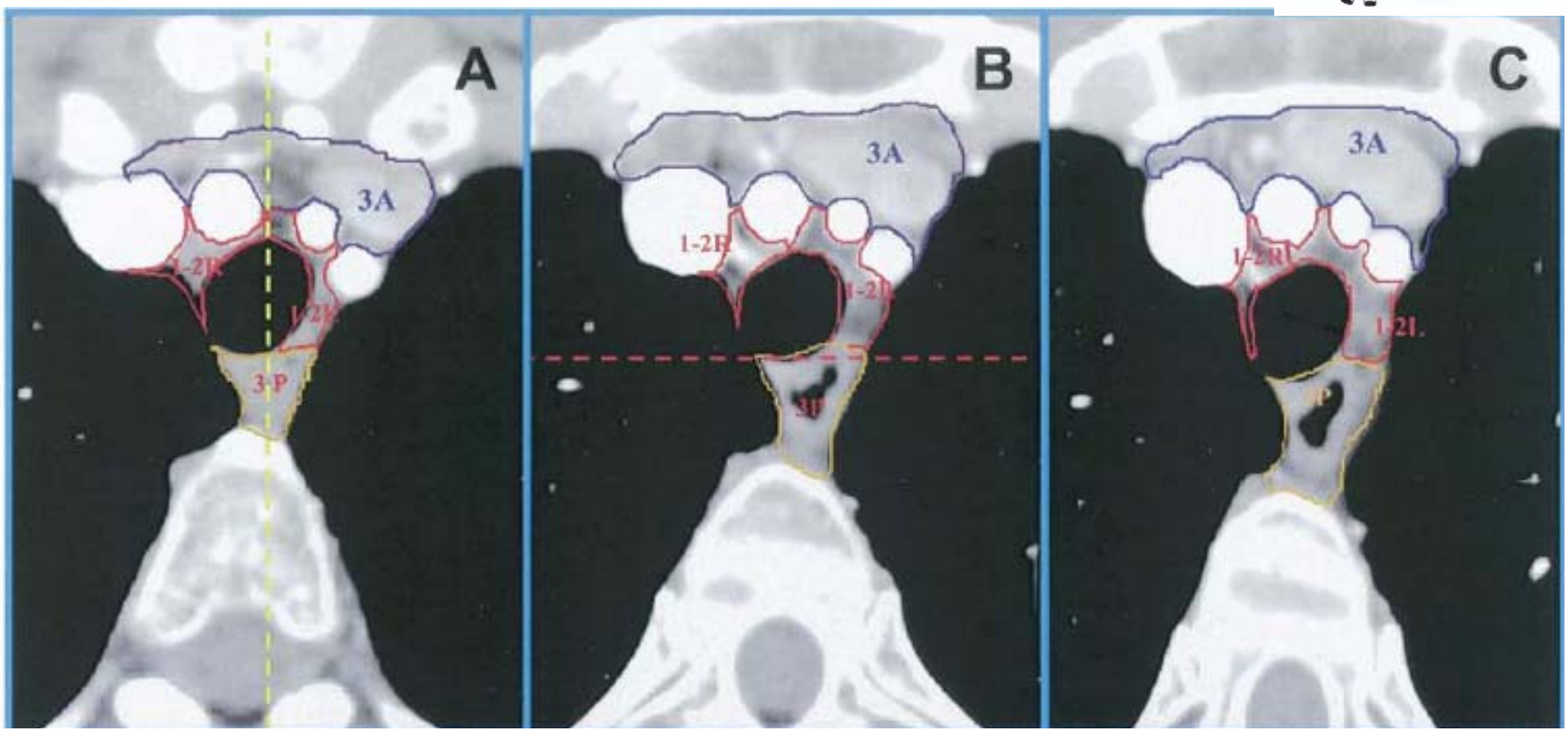
# Nodal stations of thorax

- 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:paraeosphageal nodes
- 10:hilar nodes
- 11:interlobar nodes



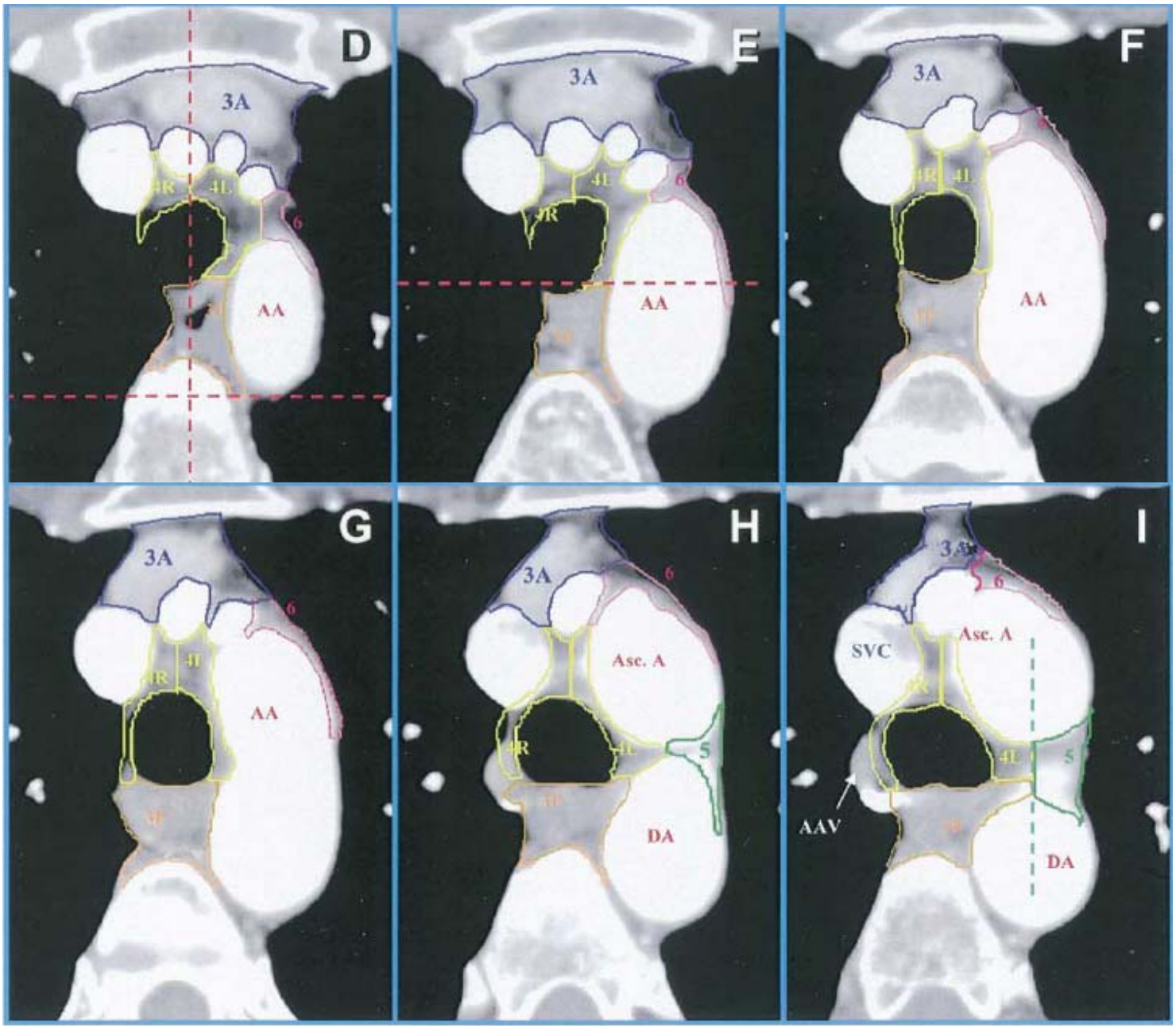
# Level 1-3

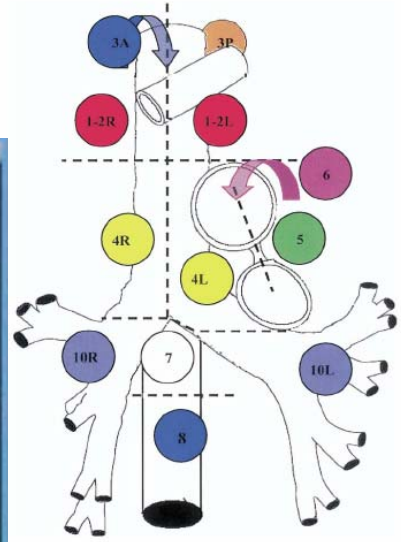


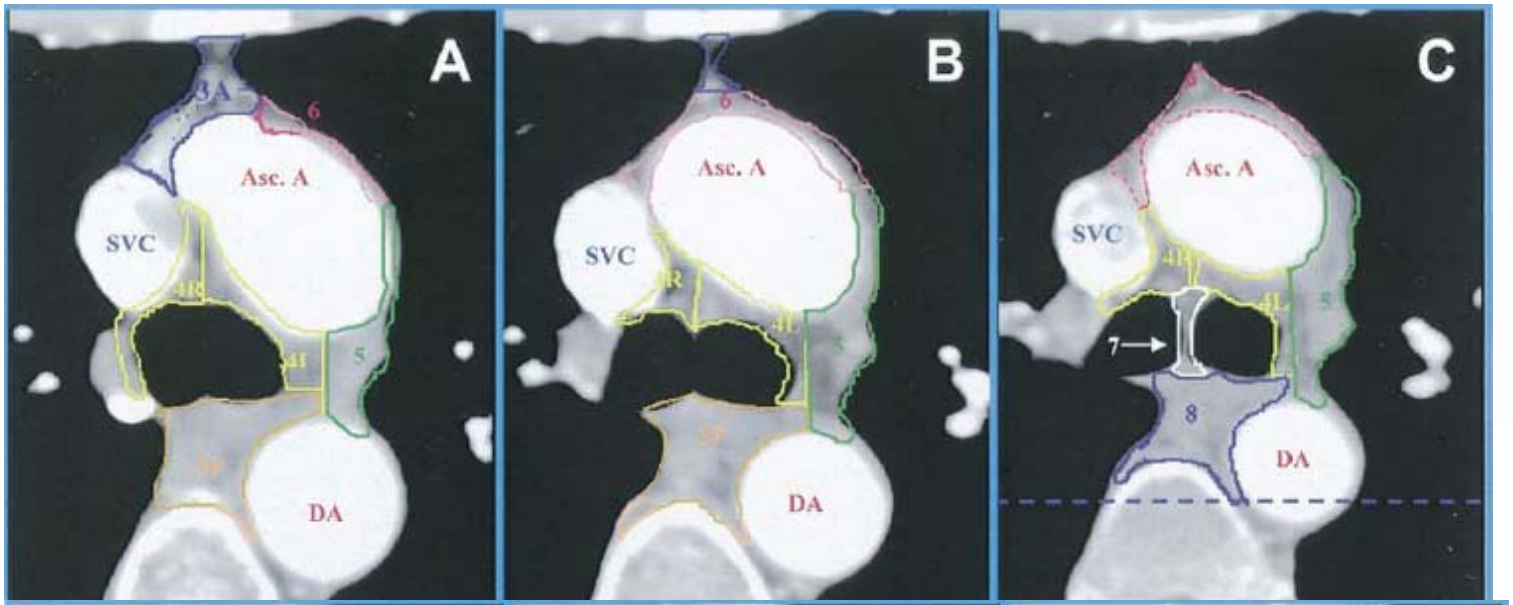

Chapet,IJROBP,2005:63;170

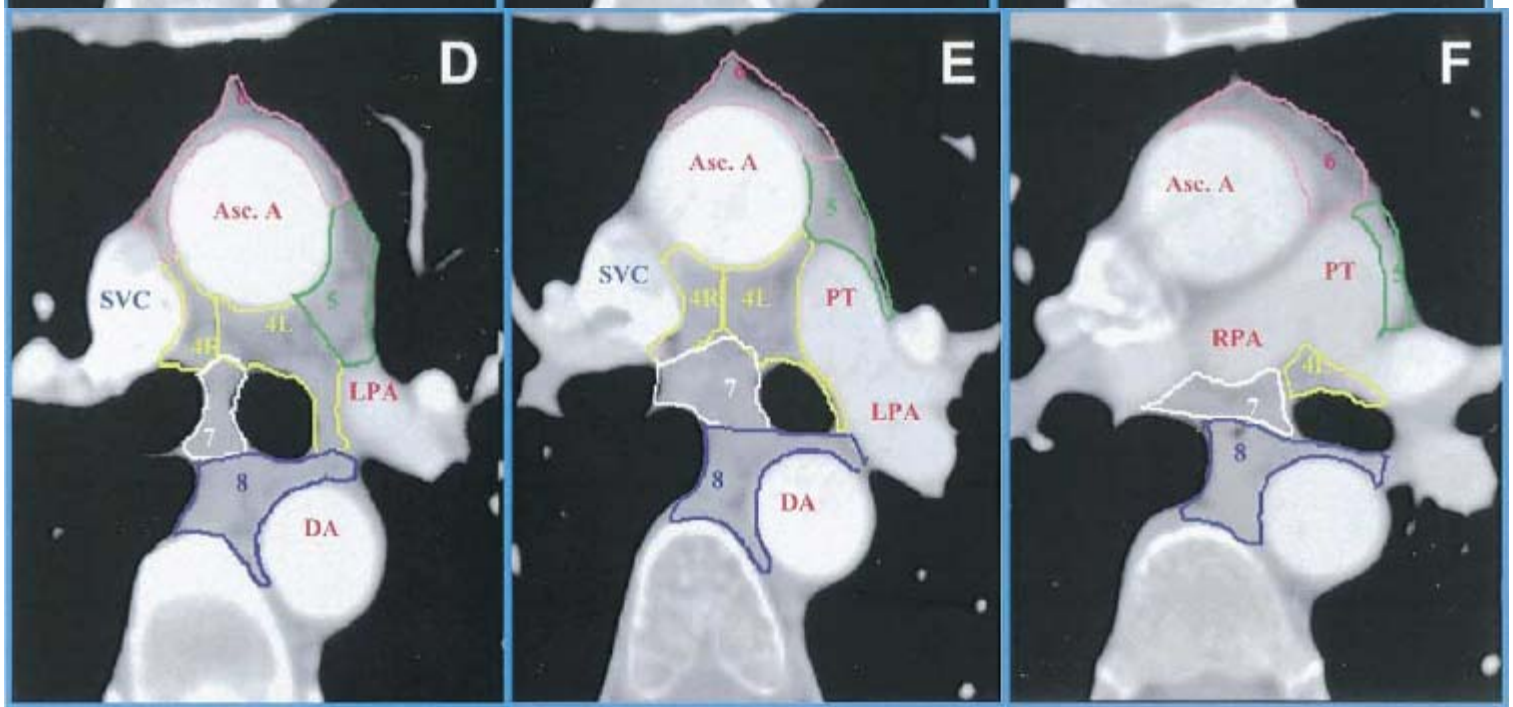
# Level 3,4,6

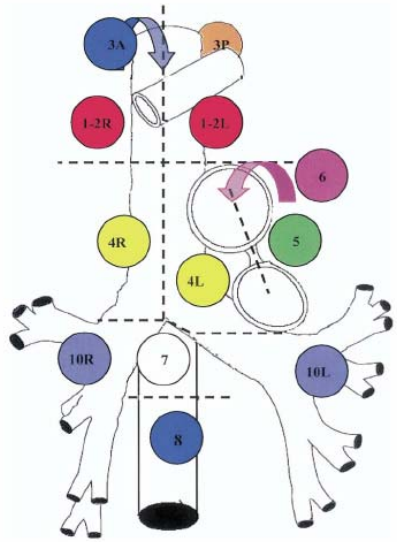

D
3A
4R
4L
6
AA
E
3A
4L
6
4R
AA
F
3A
4R
4L
AA
G
3A
6
4R
4L
AA
H
3A
6
Asc. A
4R
4L
5
DA
I
3A
6
SVC
Asc. A
4L
5
AAV
DA


3A
3P
1-2R
1-2L
6
4R
5
4L
10R
7
10L
8

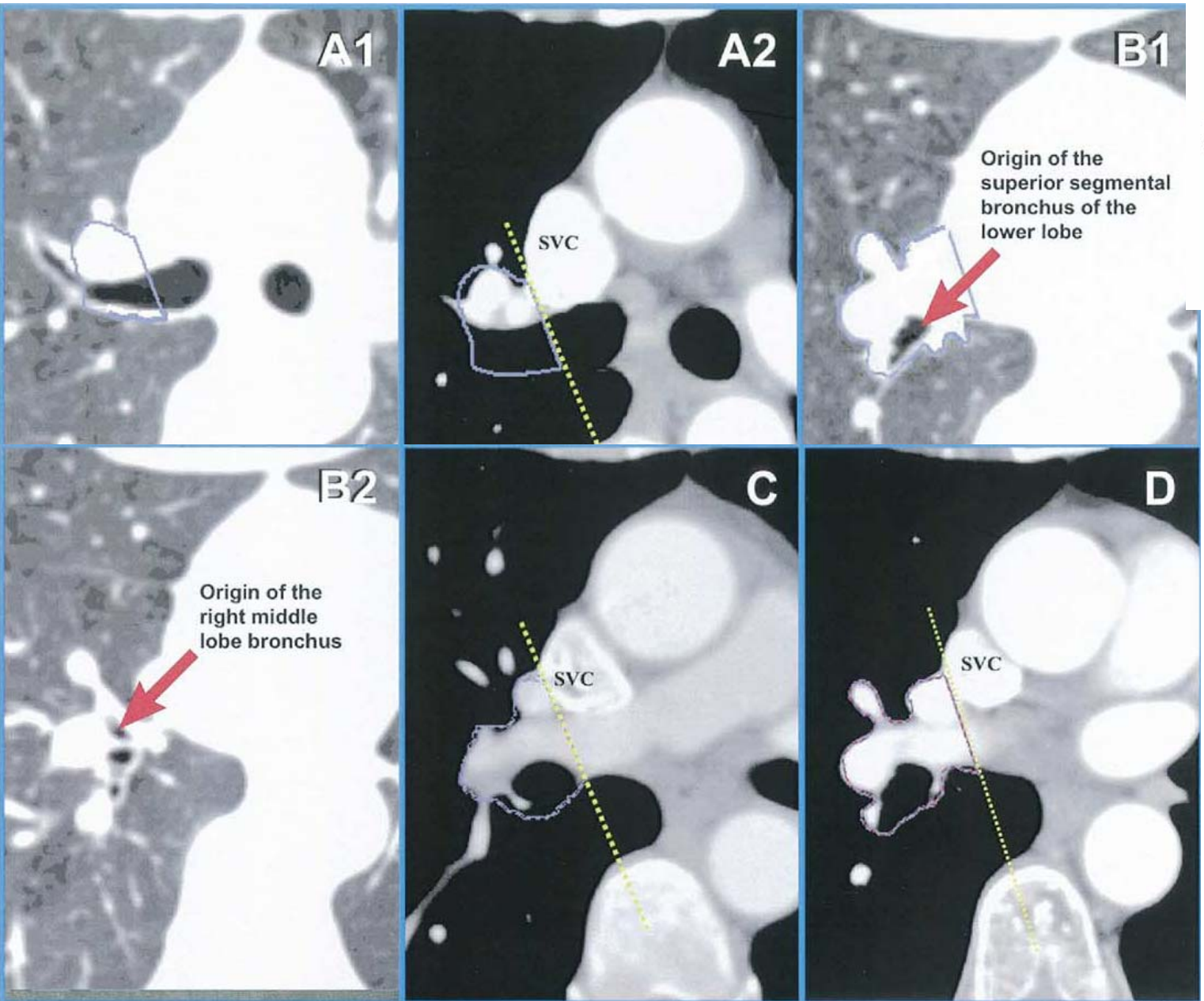
# Level 4-8

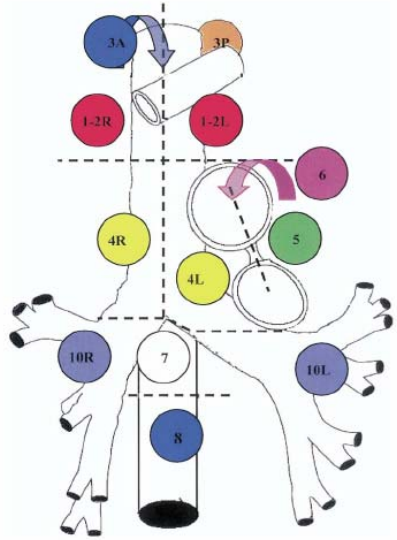

A
B
C
Asc. A
SVC
DA
7
8


D
E
F
Asc. A
SVC
4R
4L
5
LPA
PT
RPA
7
8
DA

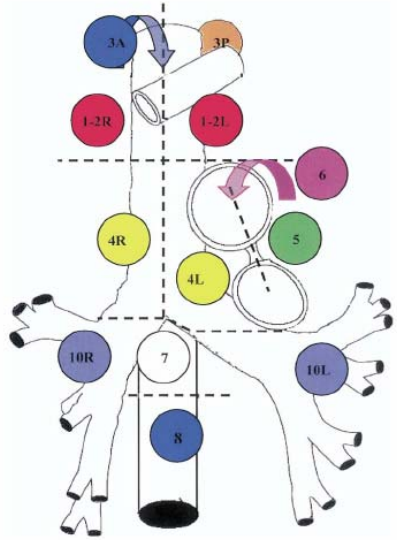

3A
3P
1-2R
1-2L
6
4R
5
4L
10R
7
10L
8

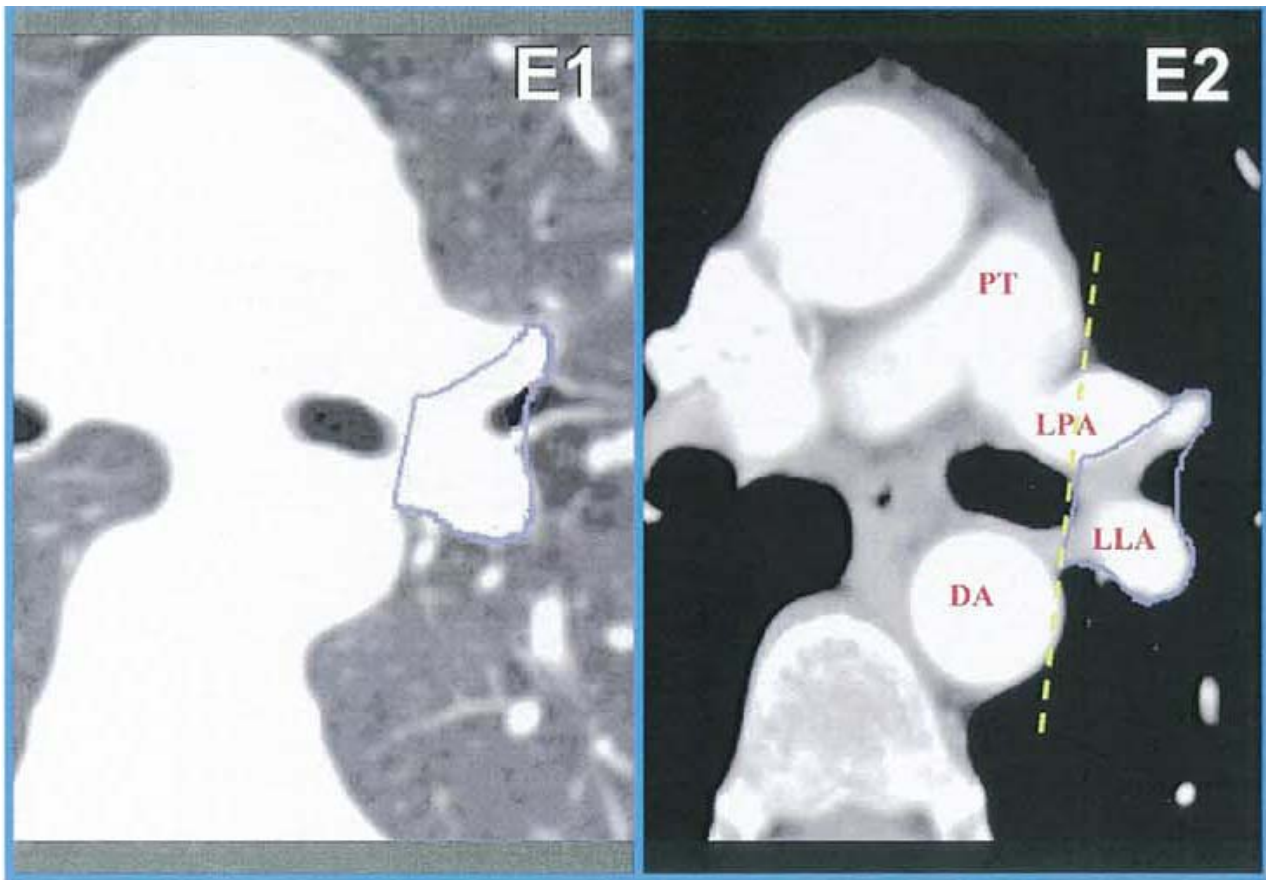
# Level 10-11R


A1
A2
SVC
B1
Origin of the superior segmental bronchus of the lower lobe
B2
Origin of the right middle lobe bronchus
C
SVC
D
SVC

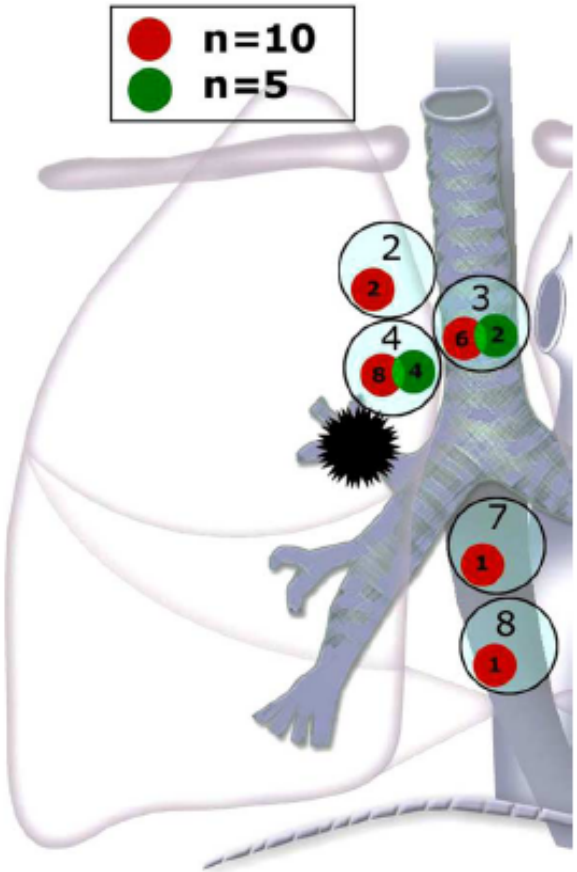

3A
3P
1-2R
1-2L
6
4R
5
4L
10R
7
10L
8

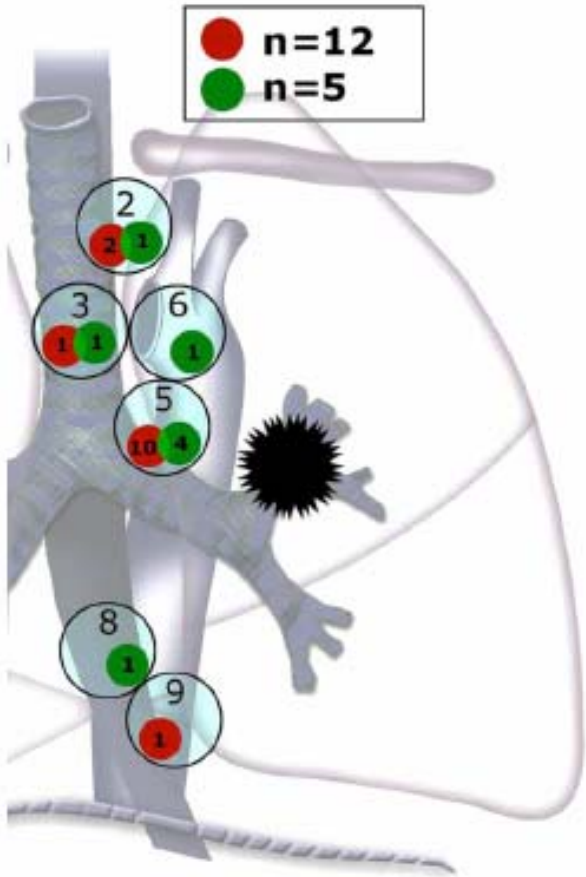
# Level 10-11L



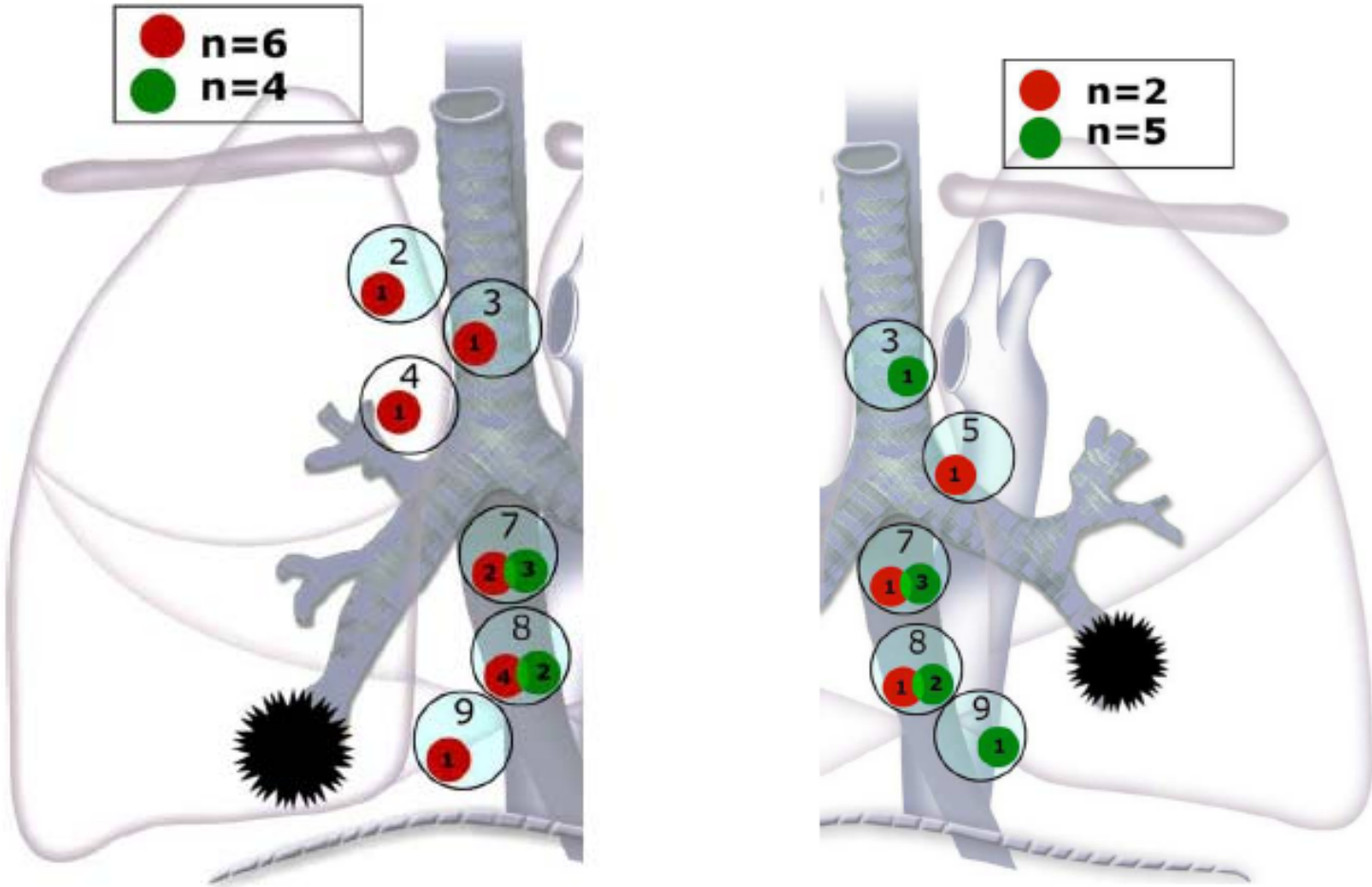



# Patterns of lymphatic drainage of lungs



# Patterns of lymphatic drainage of lungs






Kotoulas,Lung Cancer,2004:44;183

# Lymphatic drainage according to tumour site

| | 2 | 3 | 4 | 5 | 6 | 7 | 8,9 |
|---|---|---|---|---|---|---|---|
| Rt UL | | + | + | | | | |
| Rt.ML | | | + | | | + | |
| Rt.LL | | | | | | + | + |
| Rt.central | | + | + | | | + | |
| Lt.UL | | | | + | | | |
| Lt.LL | | | | | | + | + |
| Lt.central | | + | | + | + | + | |

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

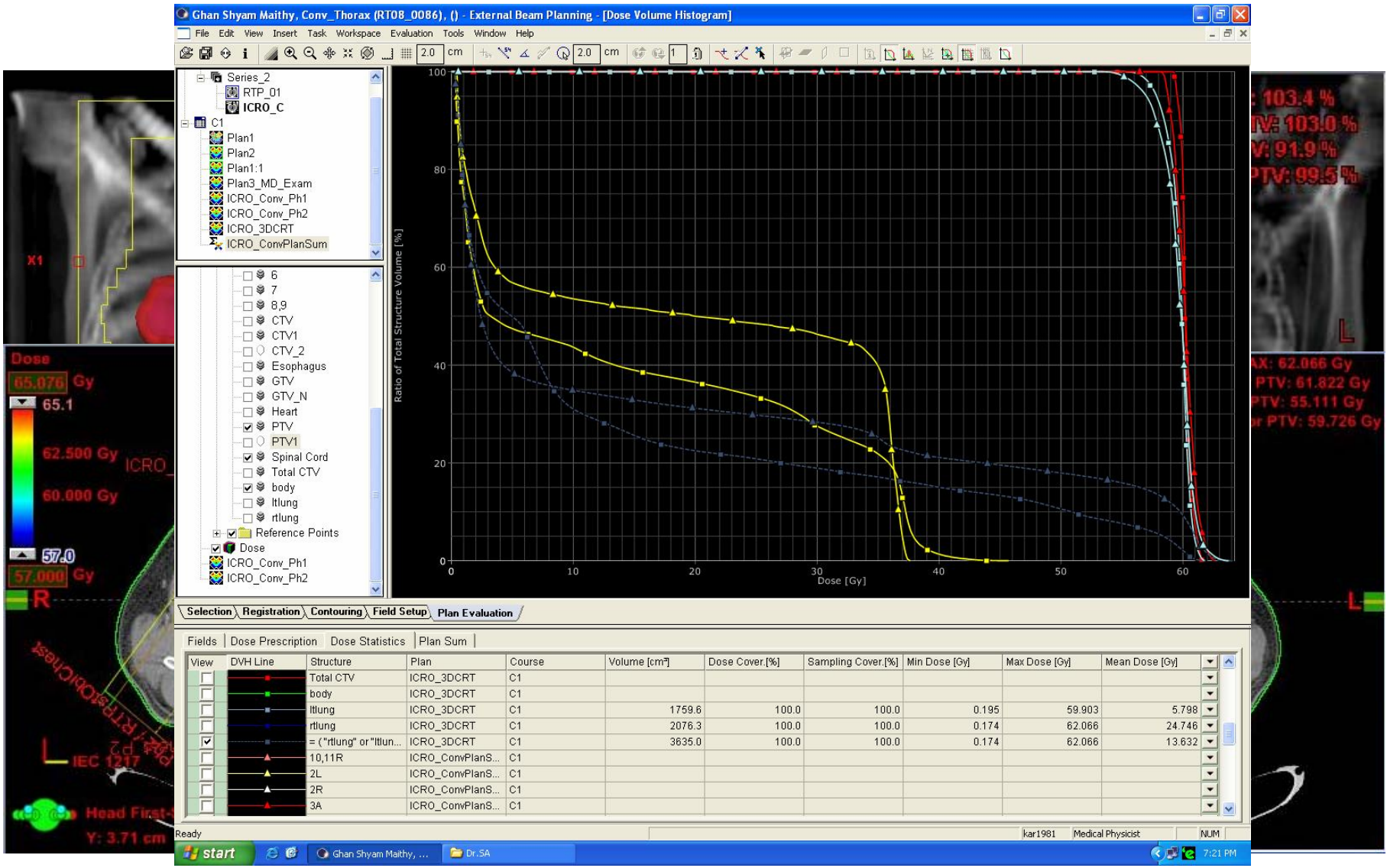
- PET

# Proposal for defining mediastinal GTV

| Nodal diameter and PET | Action |
|---|---|
| < 1cm PET +ve | Include in GTV |
| <1cm PET -ve | Exclude from GTV |
| >1cm PET +ve | Include in GTV unless cyto -ve |
| >1cm PET -ve | Include in GTV if primary PET –ve<br>IF primary PET +ve exclude from GTV |
| > 1cm or conglomerate of LN on CT | Include in GTV |

Senan et al R&O, 2004

# ENI vs INI


Ghan Shyam Maithy, Conv_Thorax (RT08_0086), () - External Beam Planning - [Dose Volume Histogram]
File Edit View Insert Task Workspace Evaluation Tools Window Help
Series_2
RTP_01
ICRO_C
C1
Plan1
Plan2
Plan1:1
Plan3_MD_Exam
ICRO_Conv_Ph1
ICRO_Conv_Ph2
ICRO_3DCRT
ICRO_ConvPlanSum
6
7
8,9
CTV
CTV1
CTV_2
Esophagus
GTV
GTV_N
Heart
PTV
PTV1
Spinal Cord
Total CTV
body
ltlung
rtlung
Reference Points
Dose
ICRO_Conv_Ph1
ICRO_Conv_Ph2
Ratio of Total Structure Volume [%]
Dose [Gy]
Selection Registration Contouring Field Setup Plan Evaluation
Fields Dose Prescription Dose Statistics Plan Sum
View DVH Line Structure Plan Course Volume [cm³] Dose Cover.[%] Sampling Cover.[%] Min Dose [Gy] Max Dose [Gy] Mean Dose [Gy]
Total CTV ICRO_3DCRT C1
body ICRO_3DCRT C1
ltlung ICRO_3DCRT C1 1759.6 100.0 100.0 0.195 59.903 5.798
rtlung ICRO_3DCRT C1 2076.3 100.0 100.0 0.174 62.066 24.746
= ("rtlung" or "ltlun... ICRO_3DCRT C1 3635.0 100.0 100.0 0.174 62.066 13.632
10,11R ICRO_ConvPlanS... C1
2L ICRO_ConvPlanS... C1
2R ICRO_ConvPlanS... C1
3A ICRO_ConvPlanS... C1
Ready
kar1981
Medical Physicist
NUM
start
Ghan Shyam Maithy, ...
Dr.SA
7:21 PM

# 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

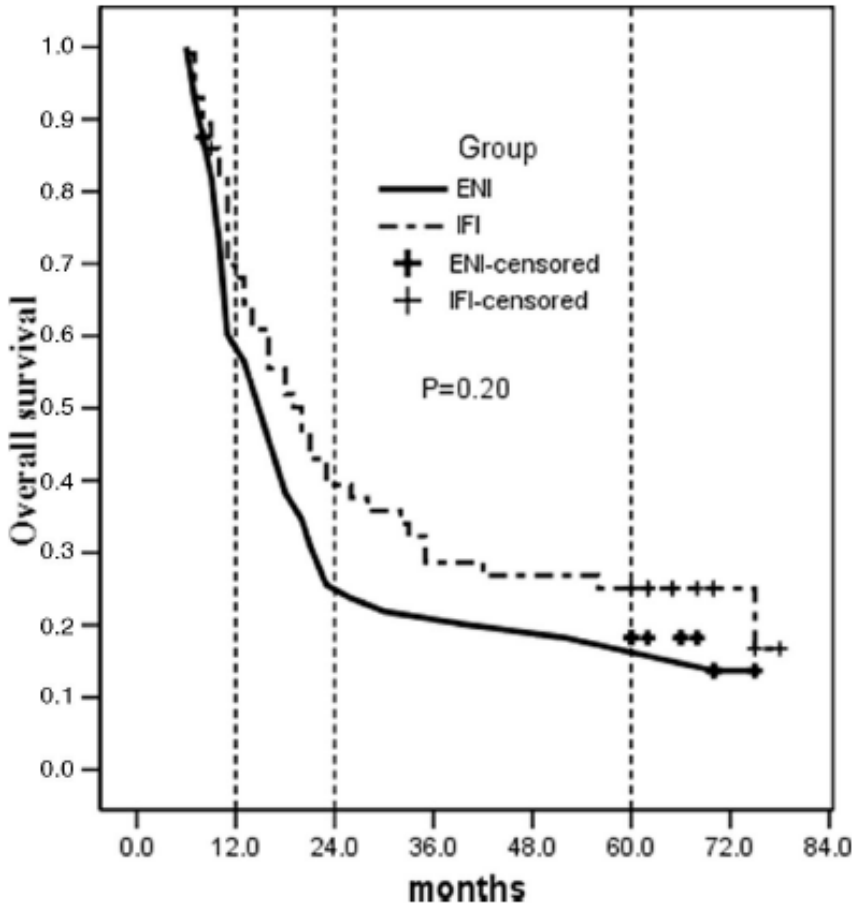
# Prospective data (ENI vs INI)

- 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

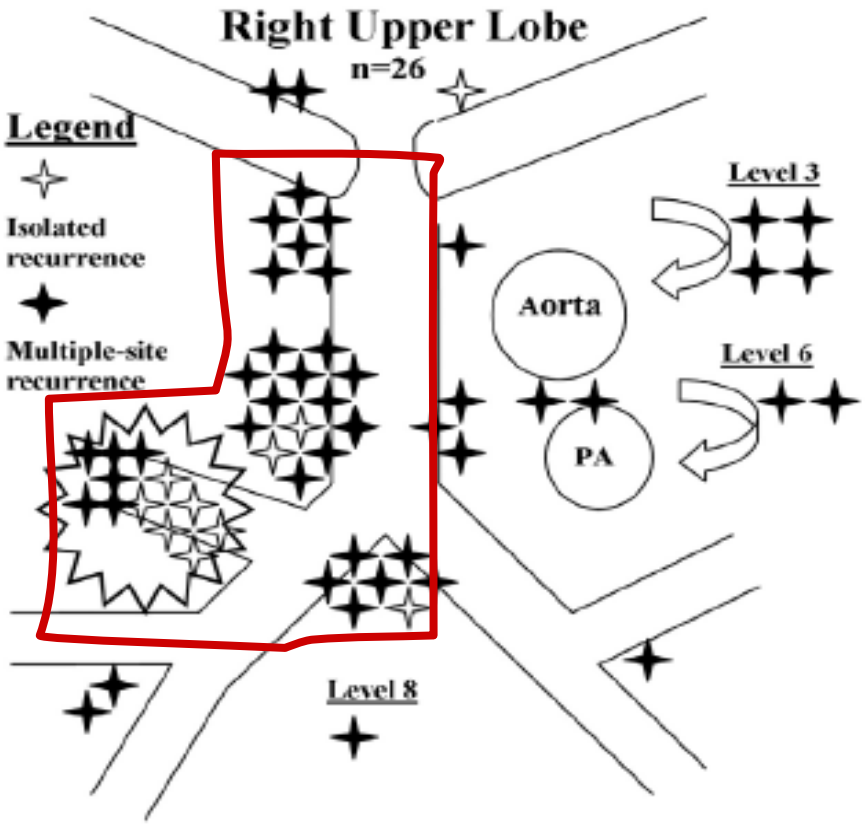
## Based on PET scan:

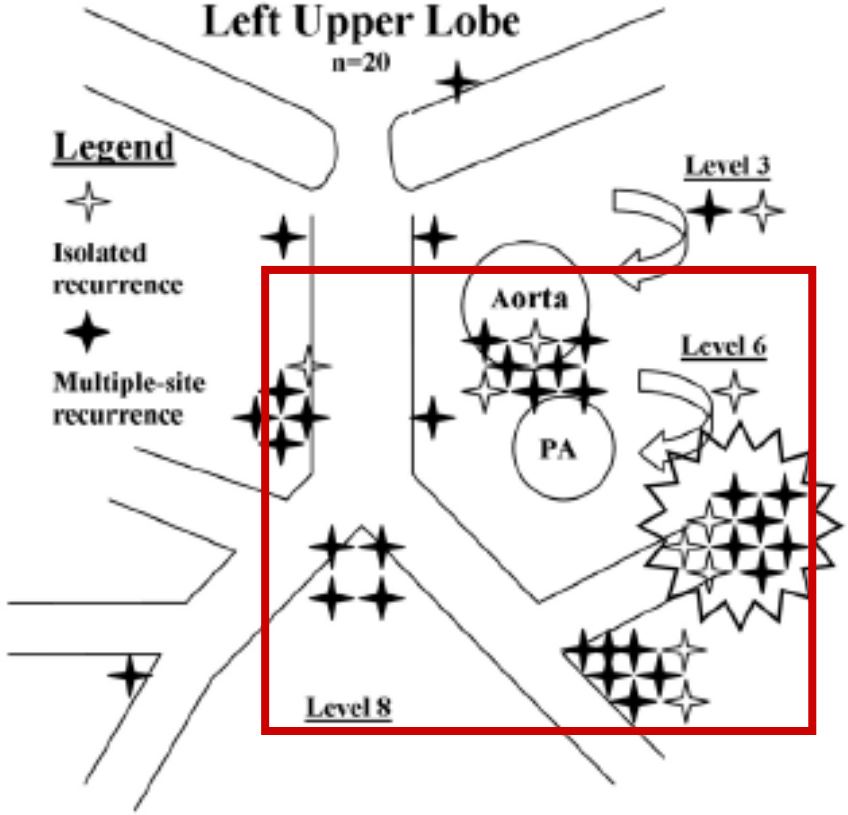
FDG PET positive tumours > SUV 3

# CTV postoperative case

# Patterns of failure after surgery

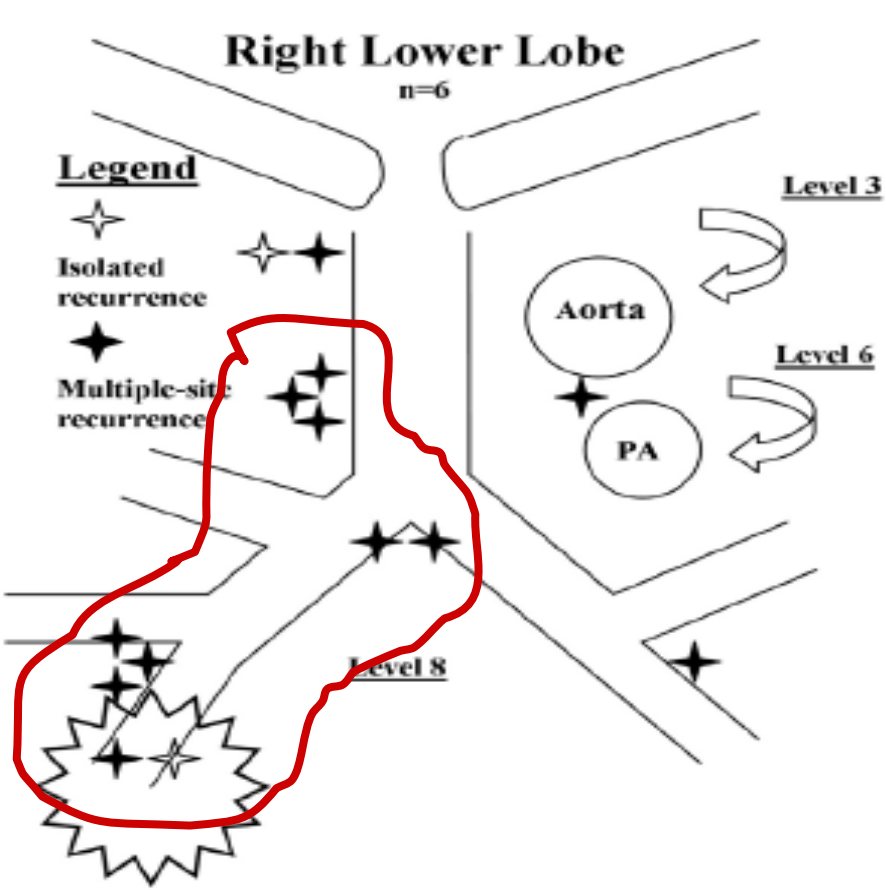
- Postop pts,c/m negative,no adjuvant RT or CT
- All SCF rec assoc with upper med inv
- All C/L rec assoc with ipsilateral relapses

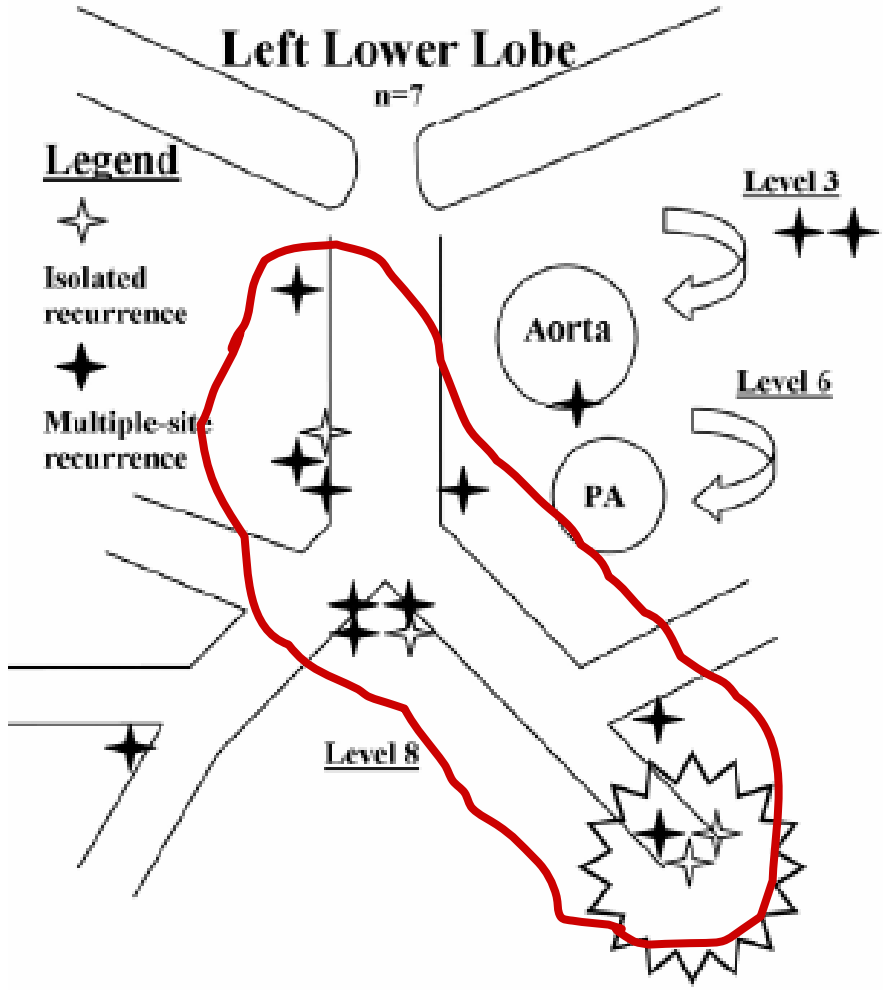



Kelsey et al 2006:65;1097

# Patterns of failure after surgery



# Radiotherapy target volumes

| Trial | Stage | Target volume | Total dose | Local failure S vs S+RT | Survival S vs S+RT |
|---|---|---|---|---|---|
| Van Houtte et al 224 | N0 | Bronchial stump,ipsilateral hilum, mediastinum | 60 | 19% vs 4% | 43% vs 24% (5yr) |
| Dautzeberg et al 728 | I-III | Bronchial stump,ipsilateral hilum, mediastinum | 60 | 34% vs 28% (5yr) | 43% vs 30% (5yr) |
| Mayer et al 155 | T1-3 N0-2 | Bronchial stump,ipsilateral hilum, mediastinum | 50-56 | 24% vs 6% | 20% vs30% (5yr) |
| Trodella 104 | T1-2, N0 | Bronchial stump,ipsilateral hilum | 50.4 | 23% vs 2% | 58% vs 67% (5yr) |

# 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