CT of the Chest

Cross-sectional anatomy made easy!

Introduction

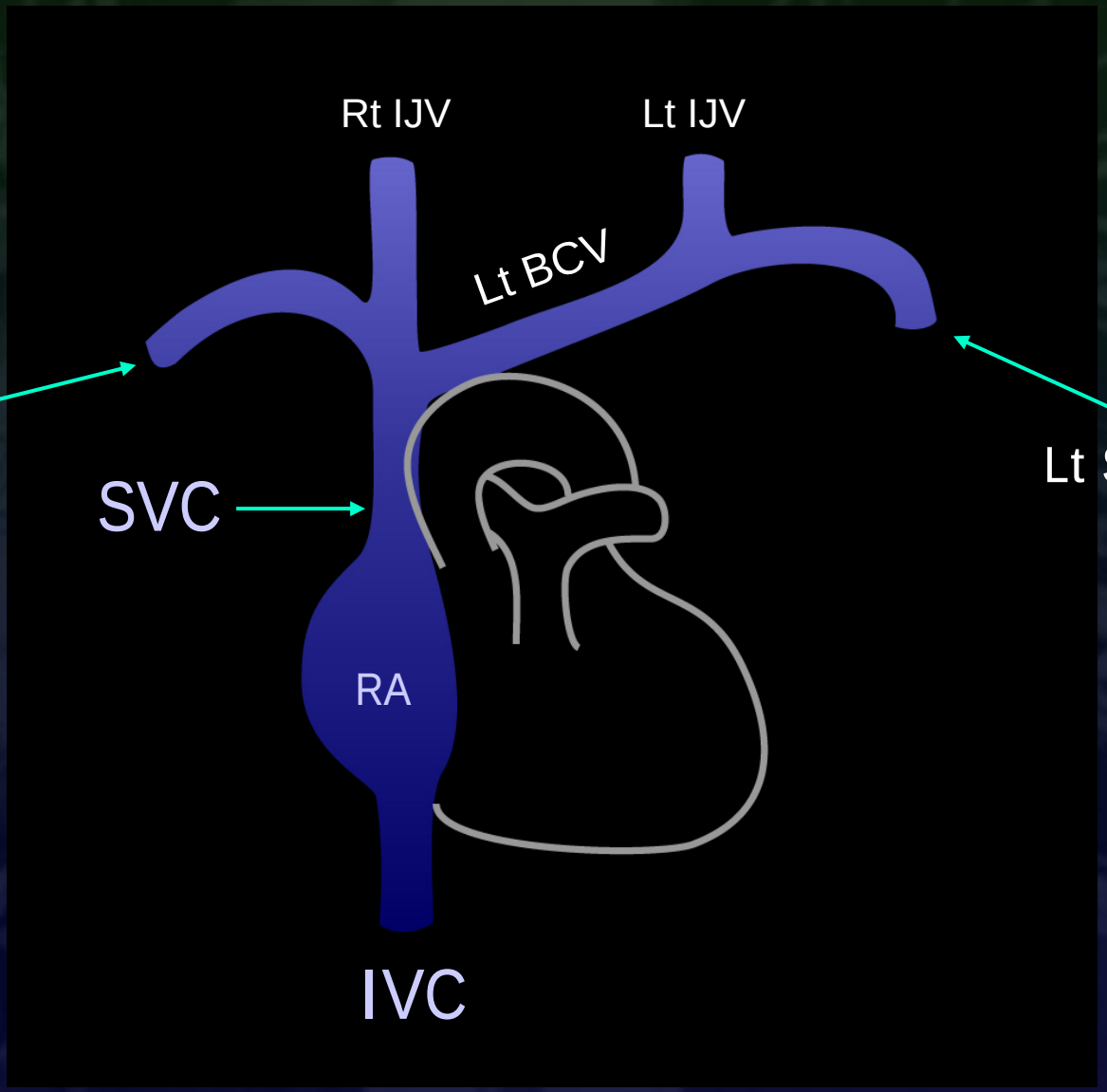
- Correlation of basic landmarks and schematic diagrams allows us to understand WHY structures appear the way they do on CT.
- This is particularly important when attempting to interpret non-contrast images.

Landmarks

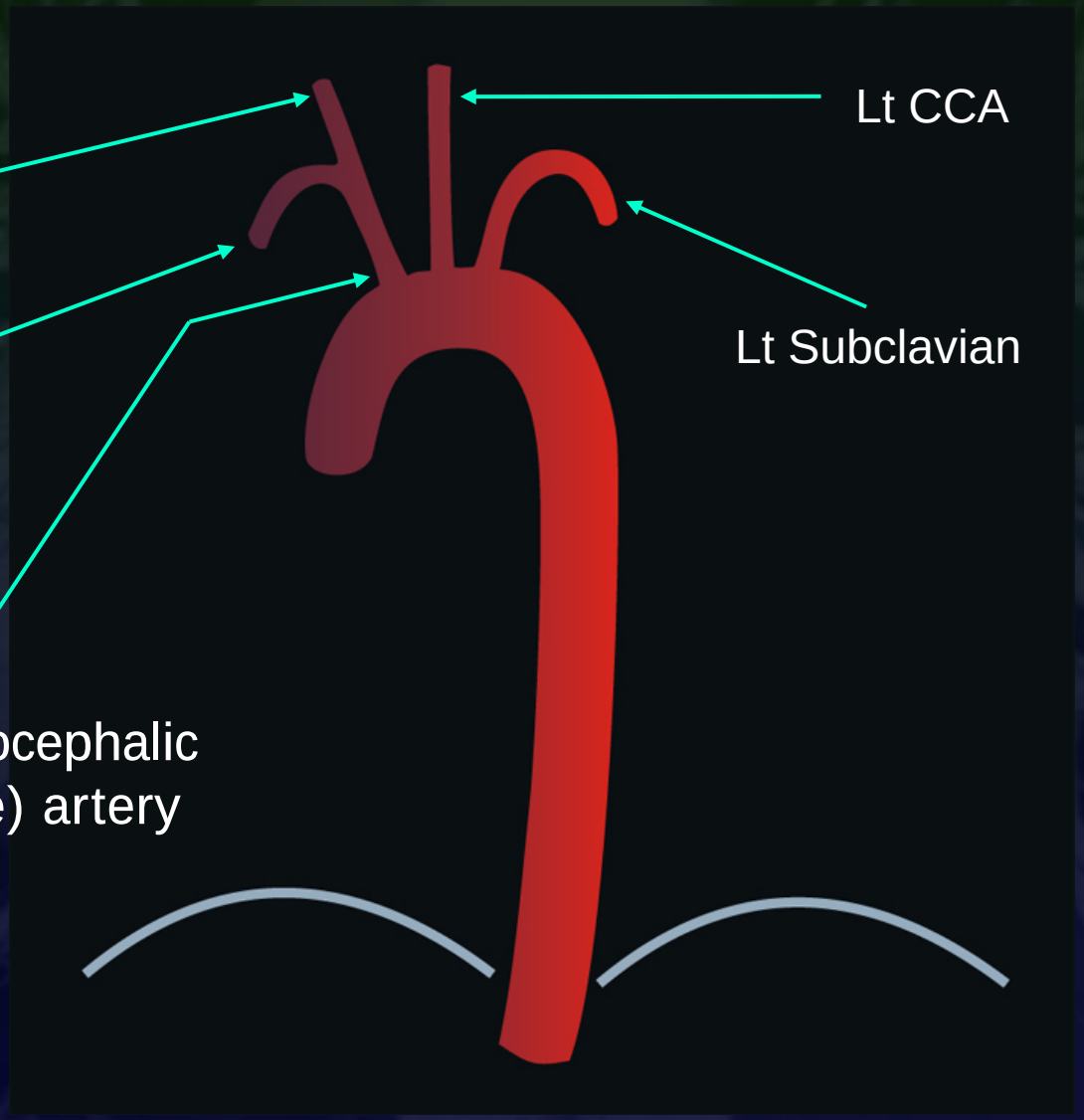
- Venous Anatomy
- Arterial Anatomy (Thoracic Aorta / Great Vessels)
- Lung Anatomy: bronchial divisions, lung fissures
- Pulmonary Circulation
- Basic Cardiac Anatomy

- Bronchopulmonary Segments
- Lymph Nodes

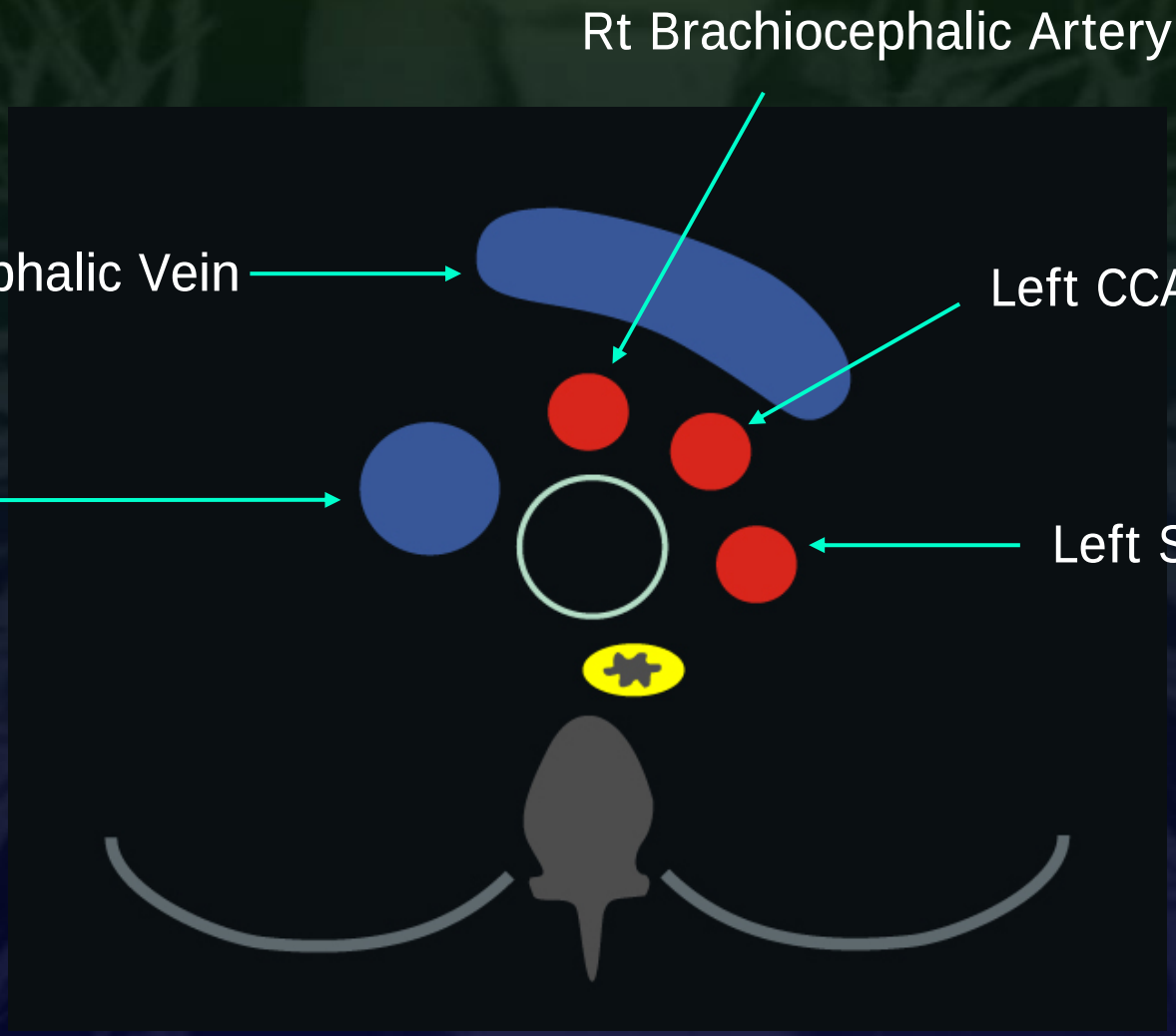
Venous Anatomy

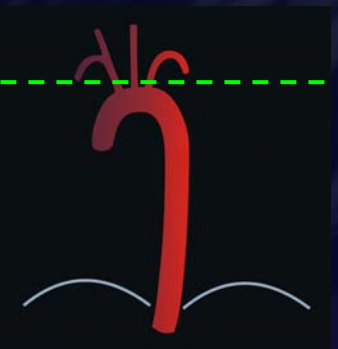


Arterial Anatomy: Thoracic Aorta

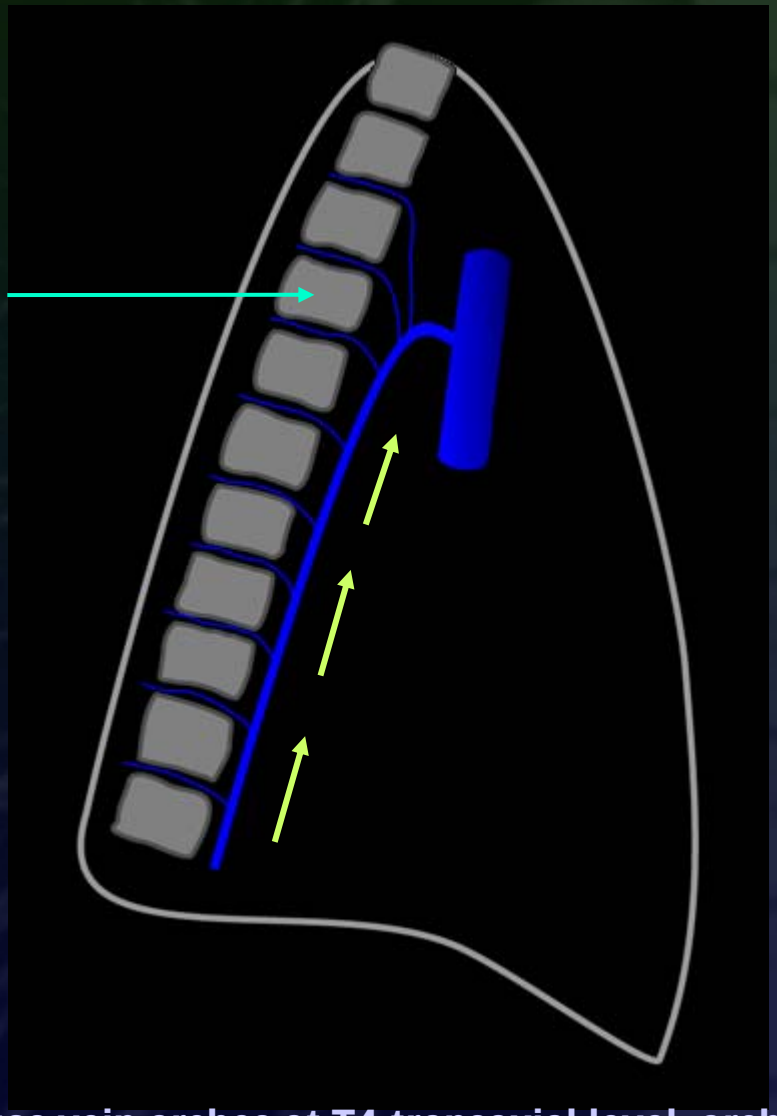


Aortic Arch Branches – axial view

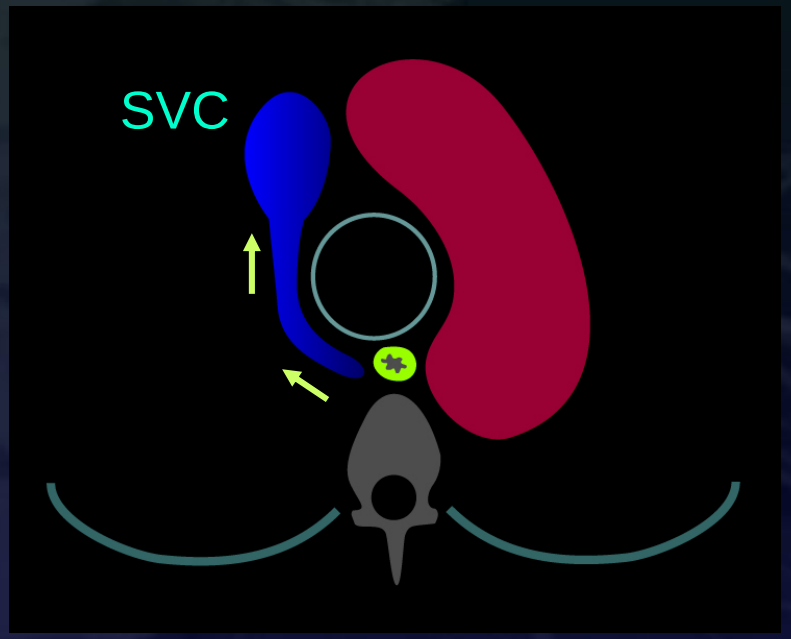




Azygos Vein



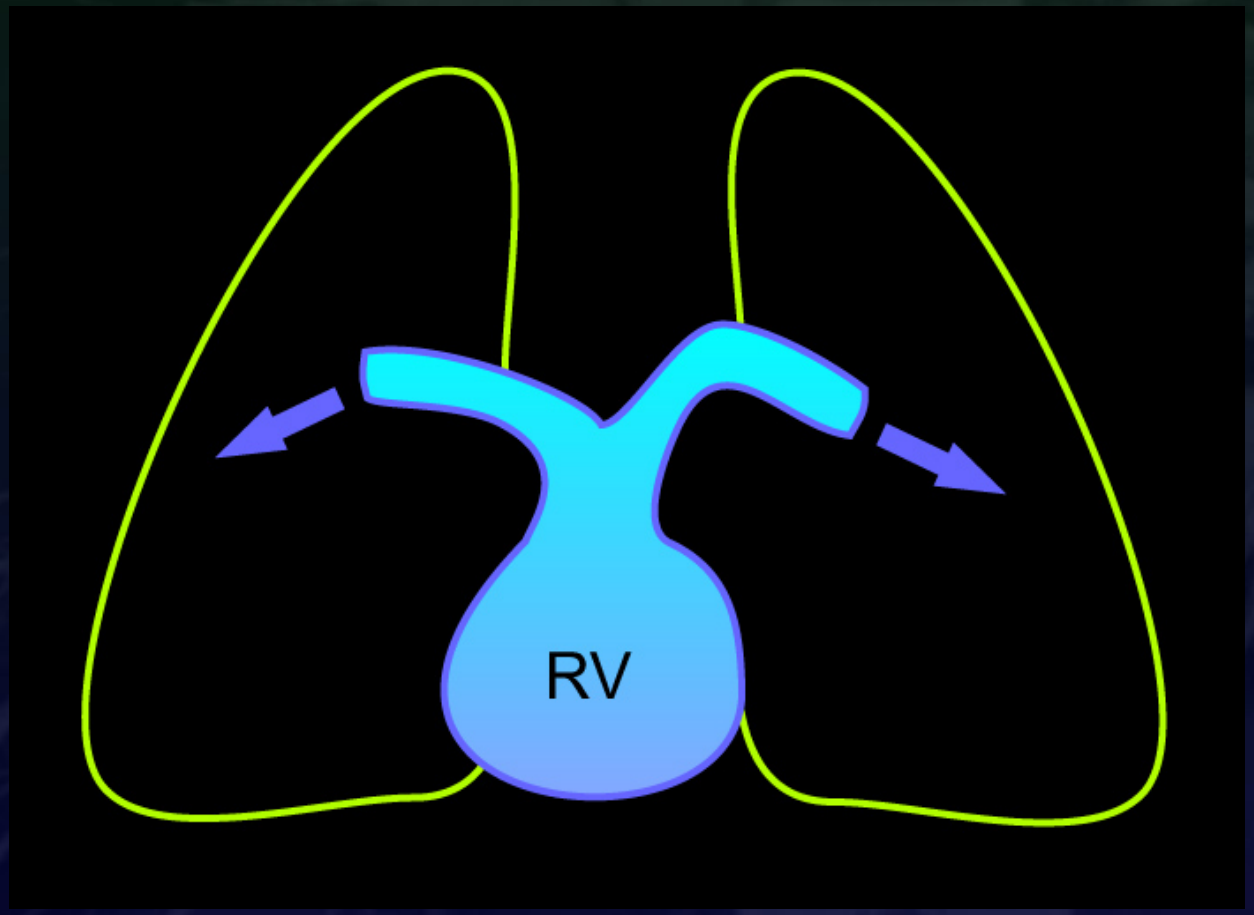
- Paravertebral location
- Drains into posterior aspect of SVC
- C-shaped configuration on axial CT (azygos arch)



Azygos vein arches at T4 transaxial level, arch over the right principle bronchus into SVC before the letter pierces the pericardium.

Pulmonary Arteries

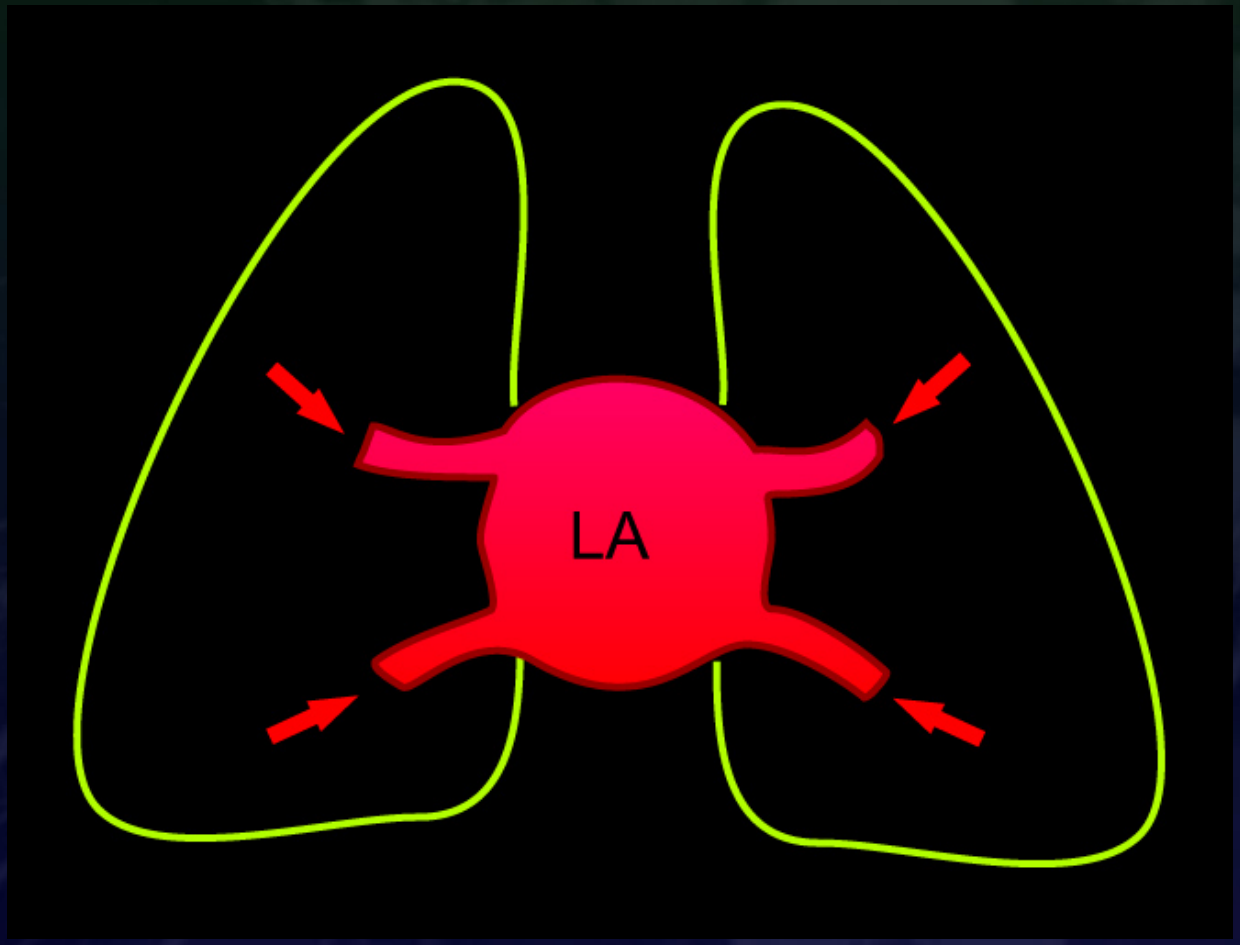
The pulmonary trunk forms the right ventricular outflow tract, and divides into right and left pulmonary arteries.



Venous blood (returning from RA into RV) is carried to the pulmonary circulation via the pulmonary arteries, for oxygenation

Pulmonary Veins

There are four pulmonary veins. These drain into the left atrium and carry oxygenated blood back to the left heart.



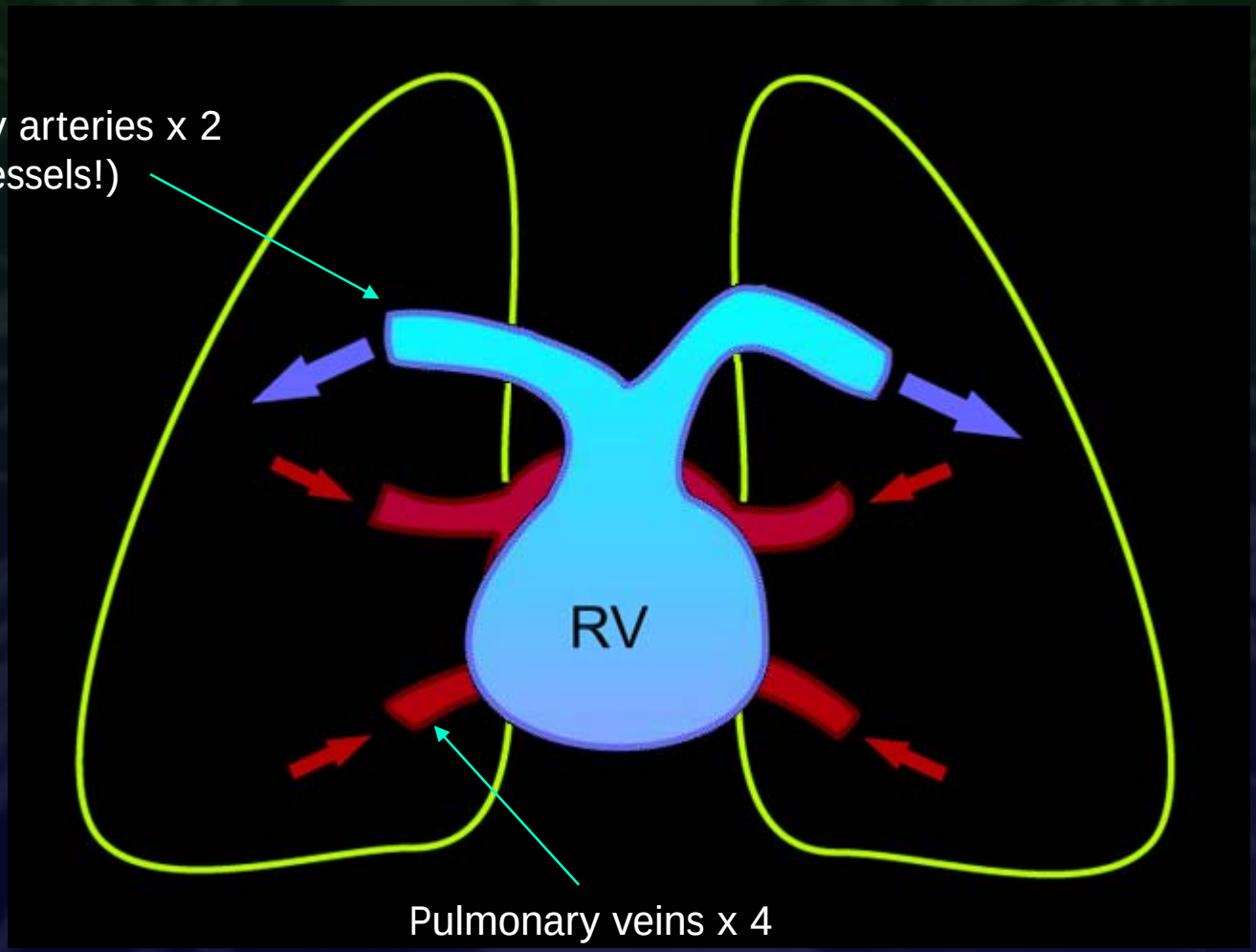
Oxygenated blood moves from LA to LV, then into the systemic circulation.

4 pulmonary veins:

- superior R and L
- inferior R and L

Pulmonary Circulation

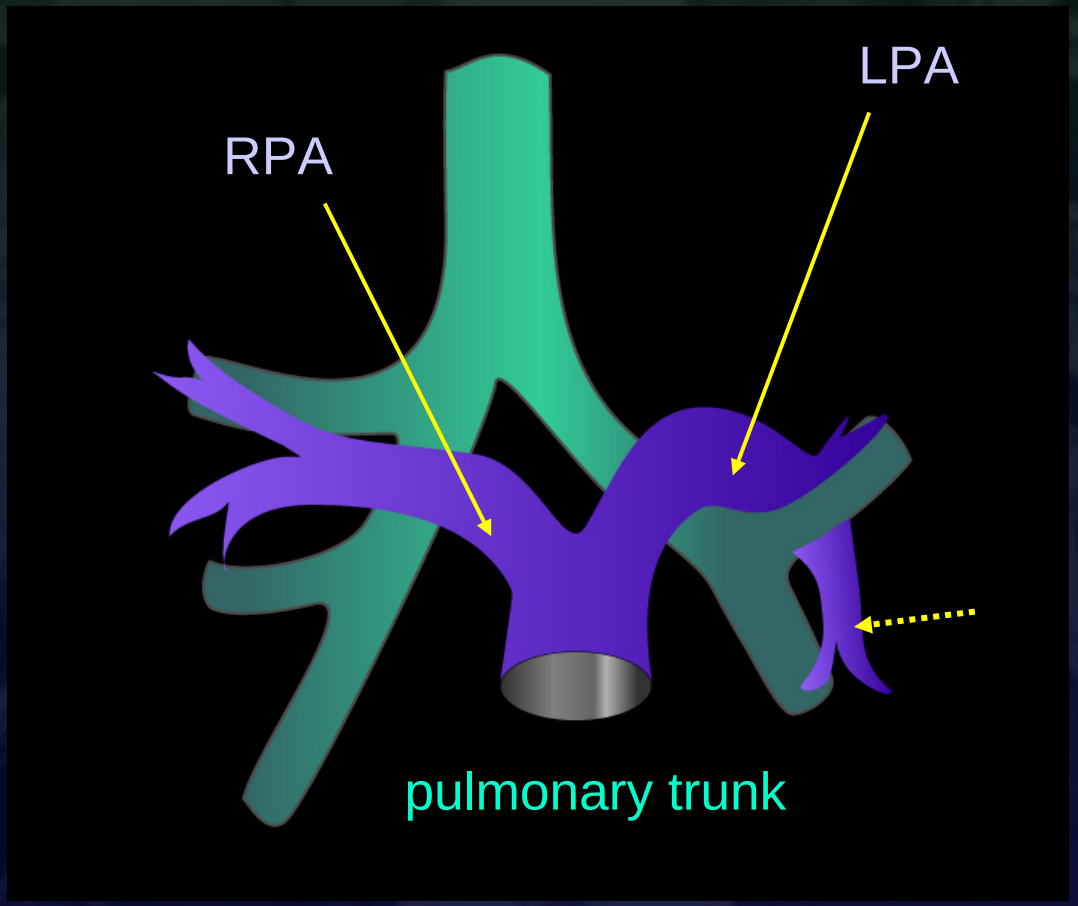
Schematic representation – pulmonary arteries and veins



Pulmonary Artery Anatomy

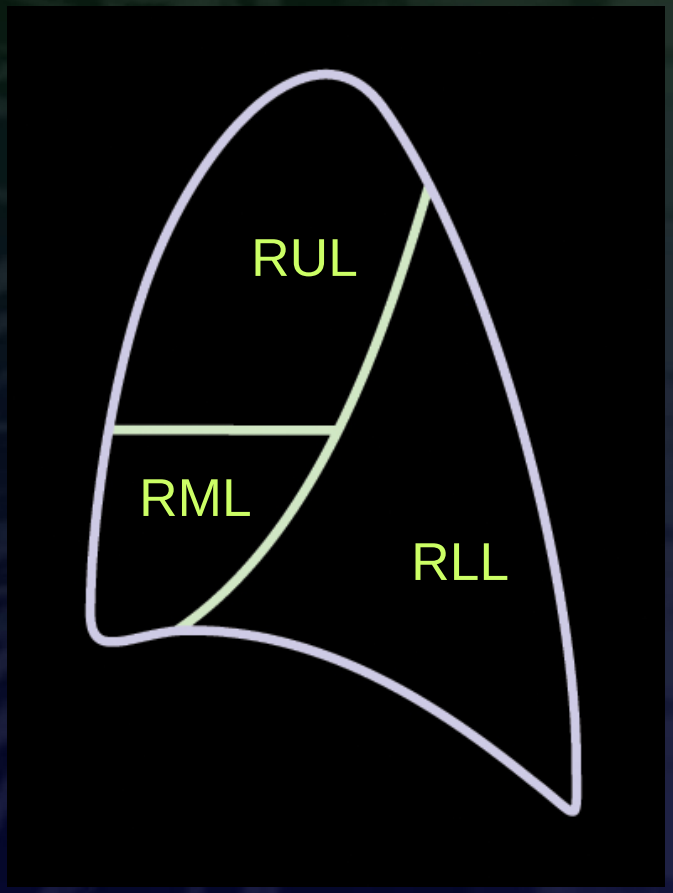
The *left pulmonary artery crosses over left main bronchus*, forming a “little arch”.

The right pulmonary artery has a relatively straight horizontal course.

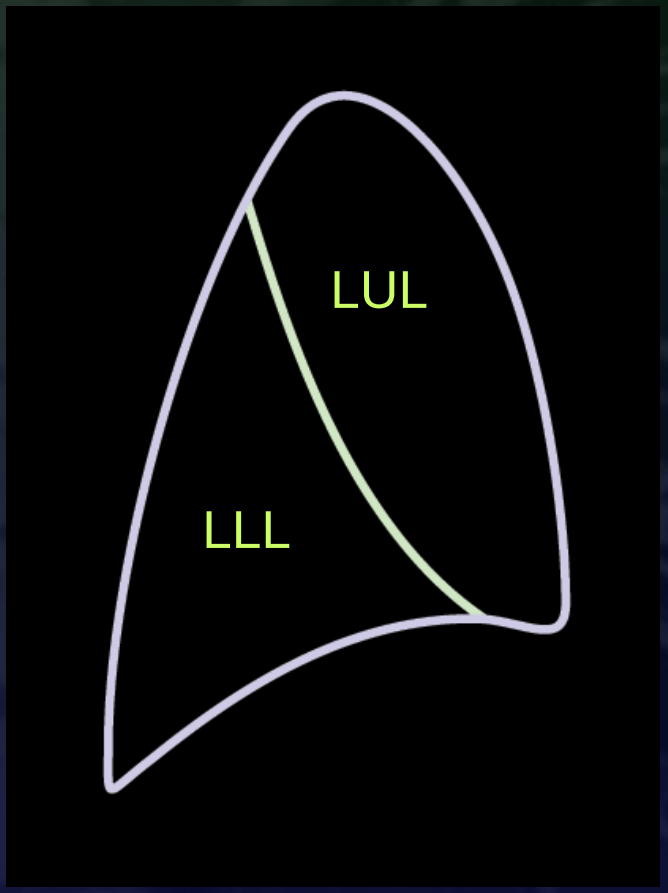


Lung Anatomy

The right lung has three lobes (upper, middle, lower)
The left lung only has two (upper and lower)



right

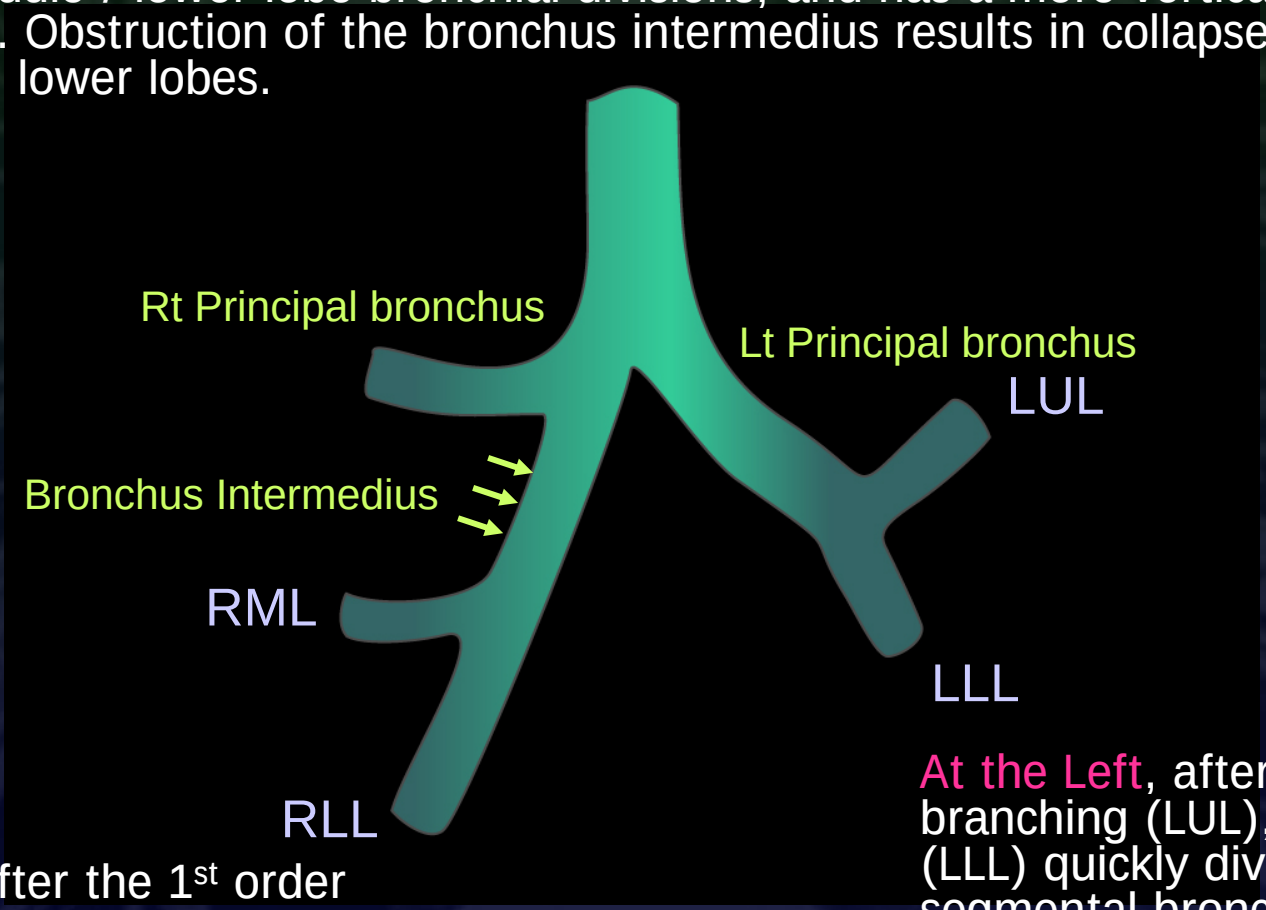


left

Bronchial Divisions

Principal Bronchus → (Bronchus Intermedius) → Lobar Bronchus → Segmental Bronchus

Bronchus Intermedius is the segment between the right upper lobe bronchus and the middle / lower lobe bronchial divisions, and has a more vertical orientation. Obstruction of the bronchus intermedius results in collapse of *both* middle and lower lobes.



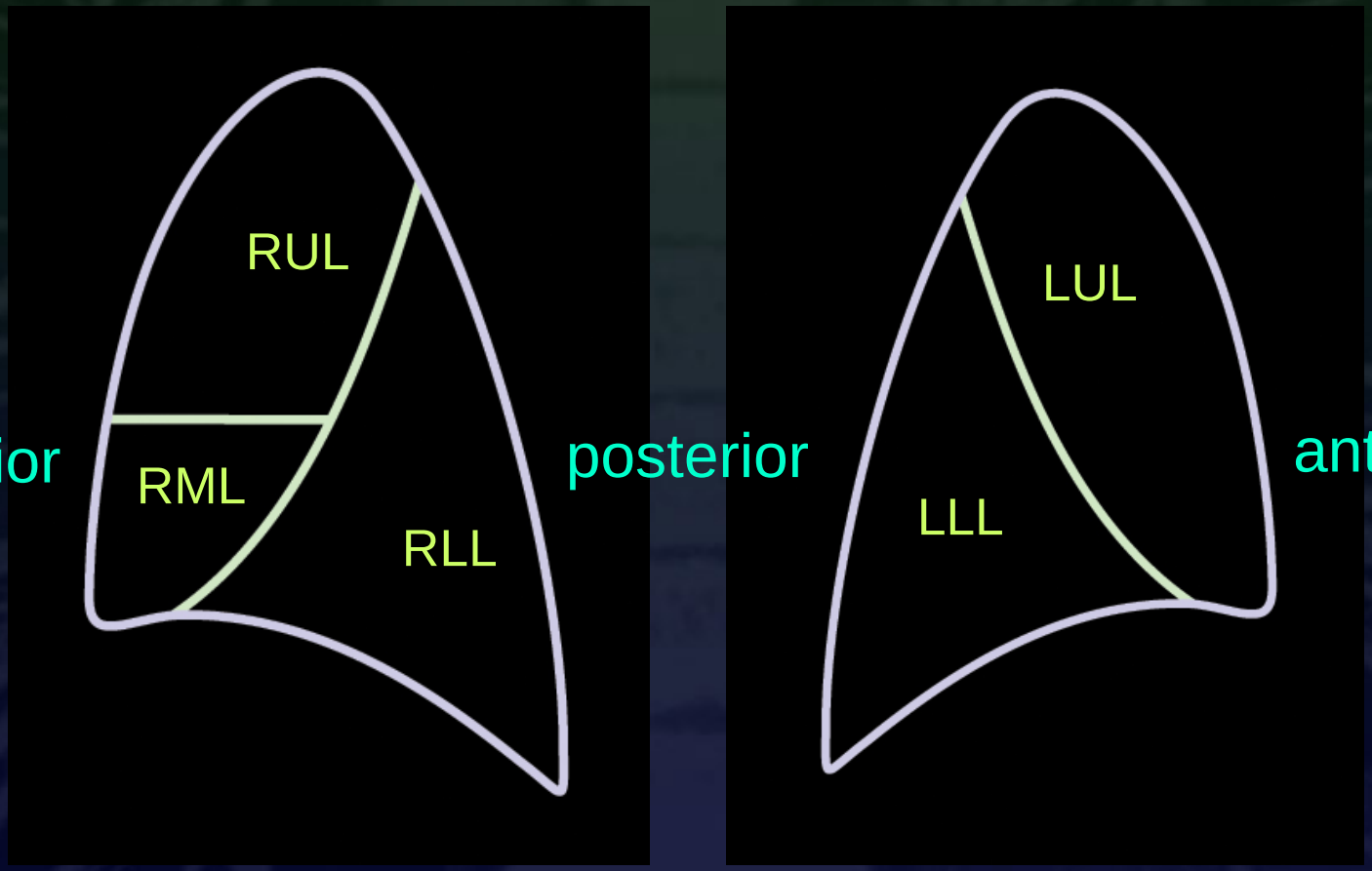
At the Right, after the 1st order branching (RUL), the bronchus travels for a distance (bronchus intermedius) before the 2nd order branching (RML & RLL).

At the Left, after the 1st order branching (LUL), the bronchus (LLL) quickly divides out into segmental bronchi.

Lung Fissures (medial views)

right

left

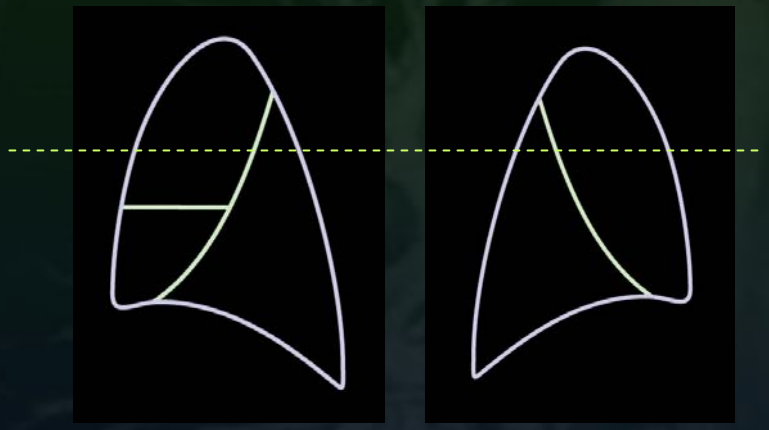


anterior

posterior

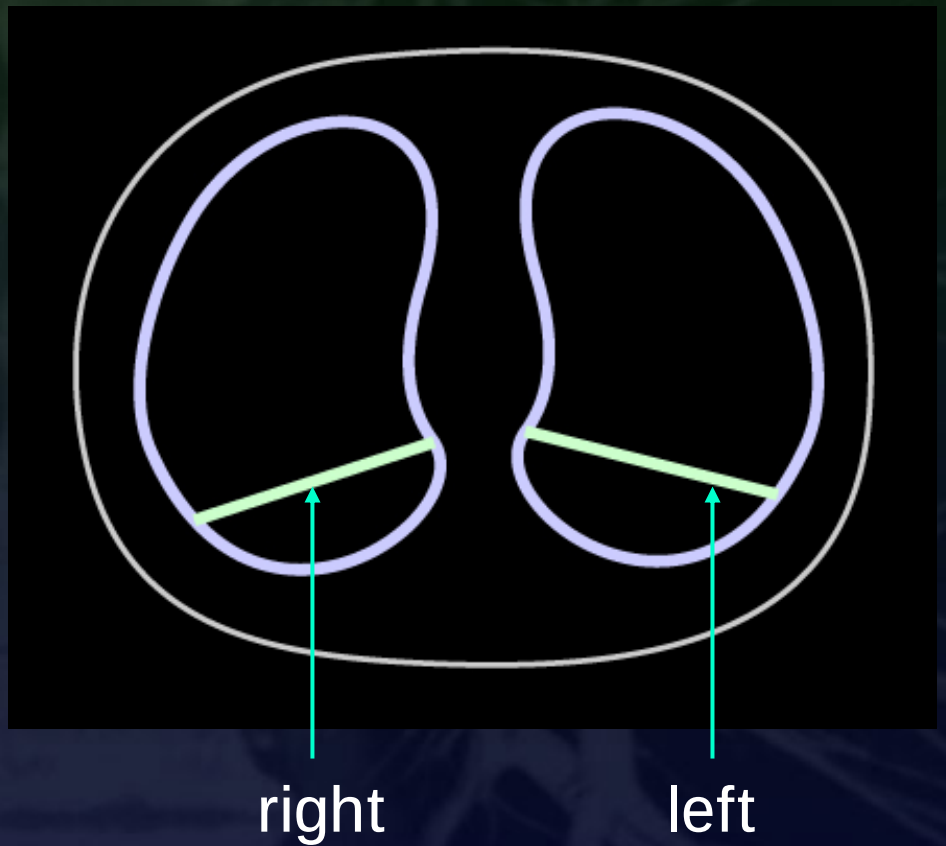
anterior

Lung fissures - axial projection



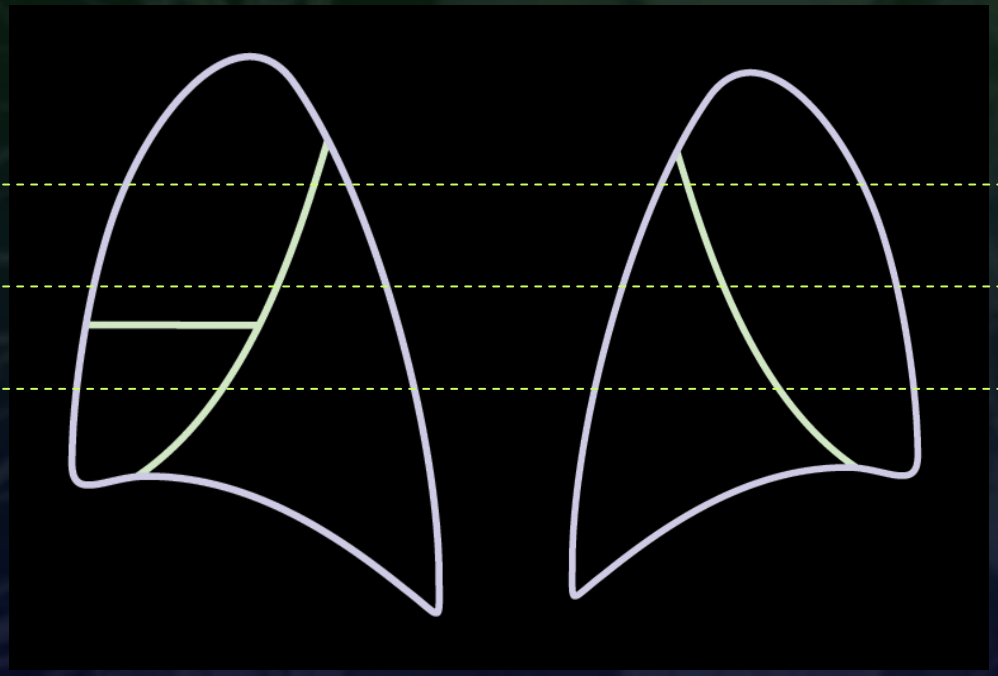
The oblique fissures lie at an angle to the CT beam and are composed of pleural reflections.

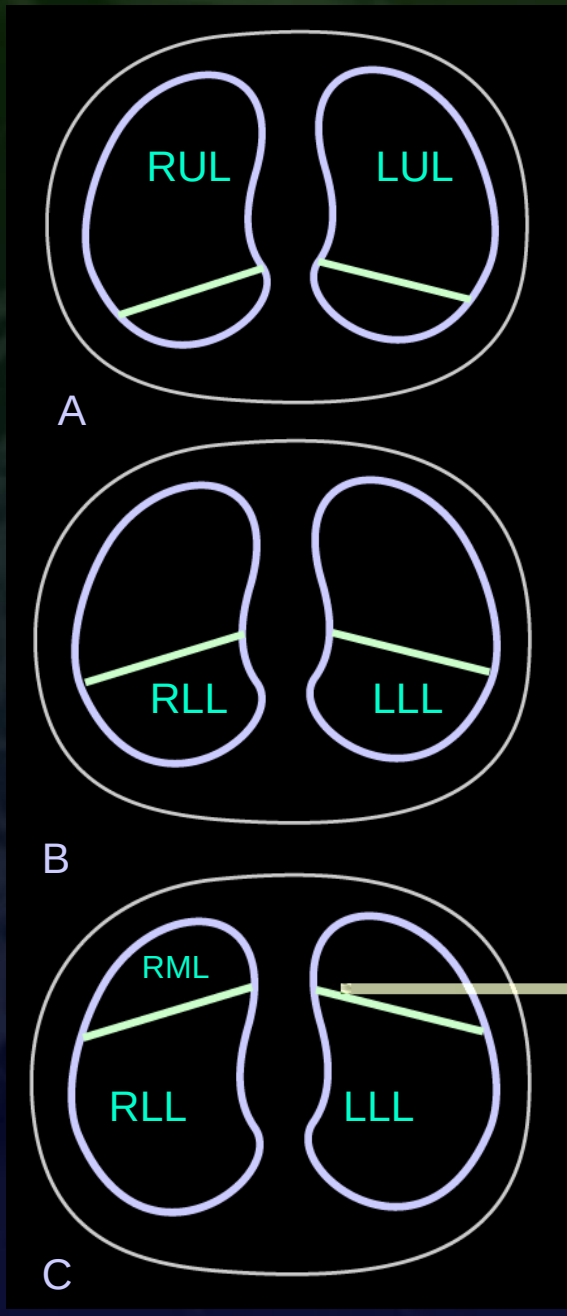
They appear as thin avascular lines (i.e. no bronchovascular markings).



oblique fissures: axial appearance

Lung fissures



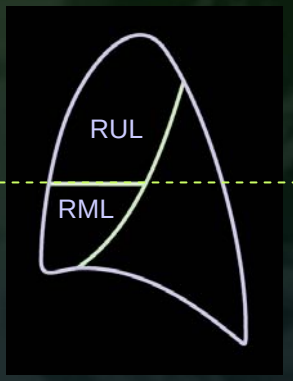


The lower lobes are more posterior and arise quite superiorly within the apices.

The oblique fissures become progressively more anterior from top to bottom.

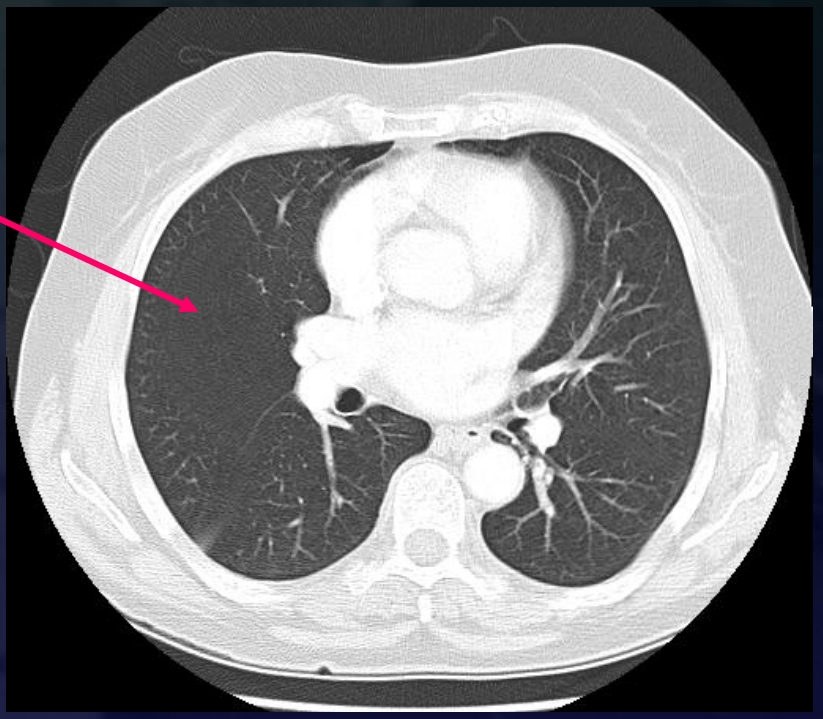
Horizontal fissure

Orientation is parallel to CT beam



Evident as an avascular area on one or two slices

(fissure is composed of pleural reflections - no bronchovascular markings)

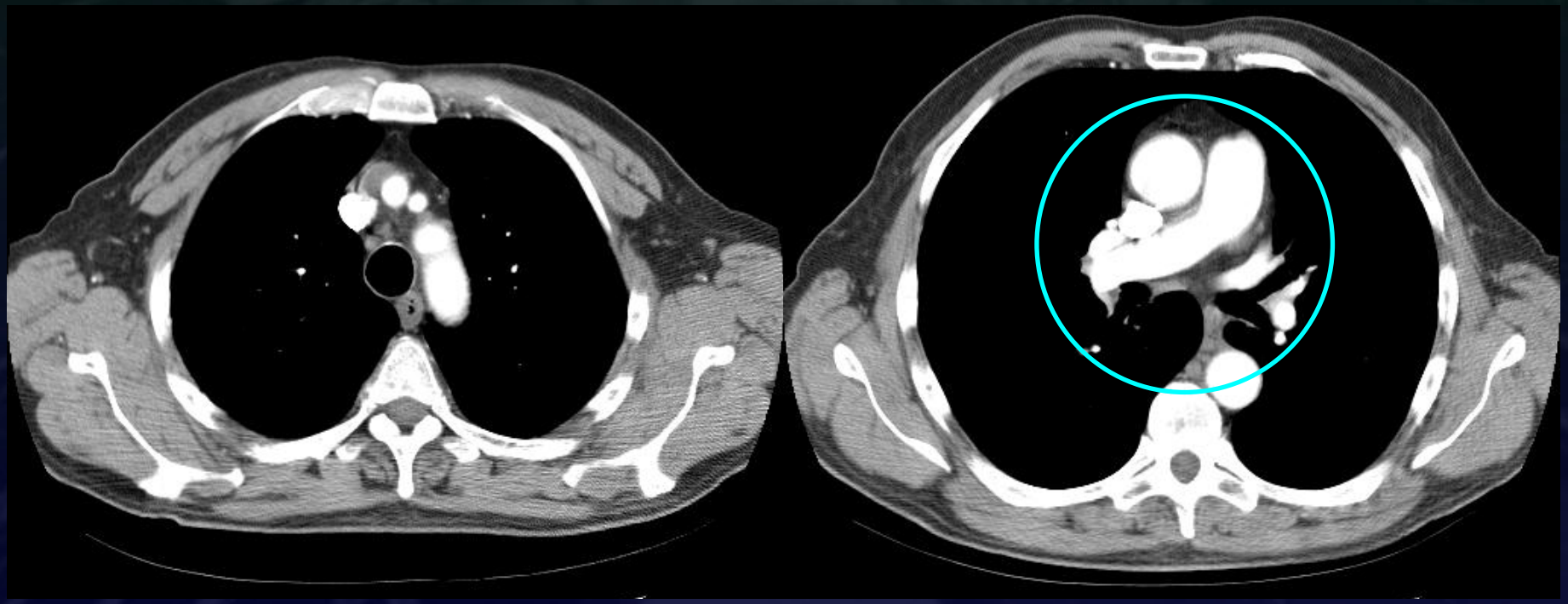


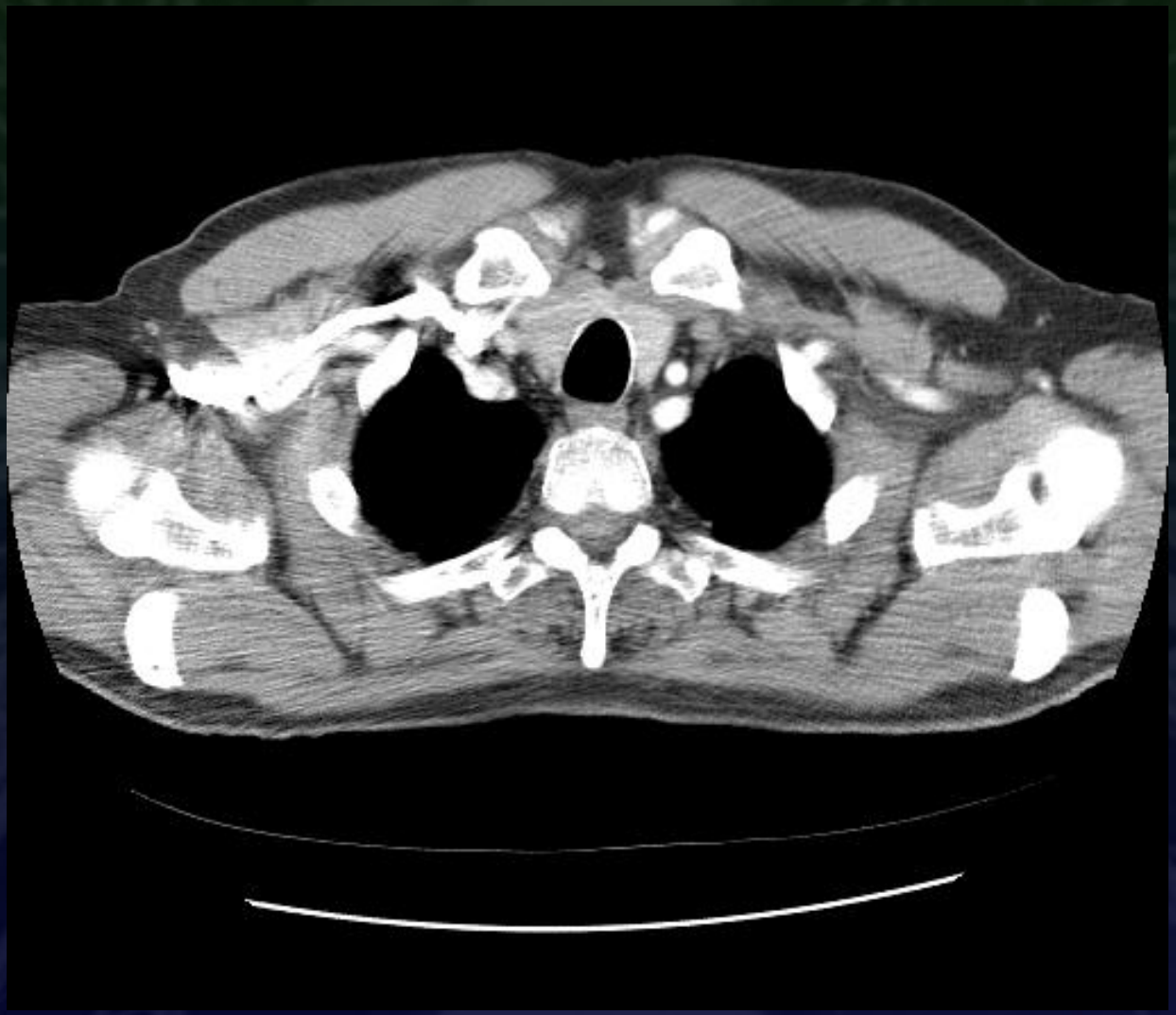
Separates the right upper lobe above from the middle lobe below

Diagnostic Chest CT - IV Contrast

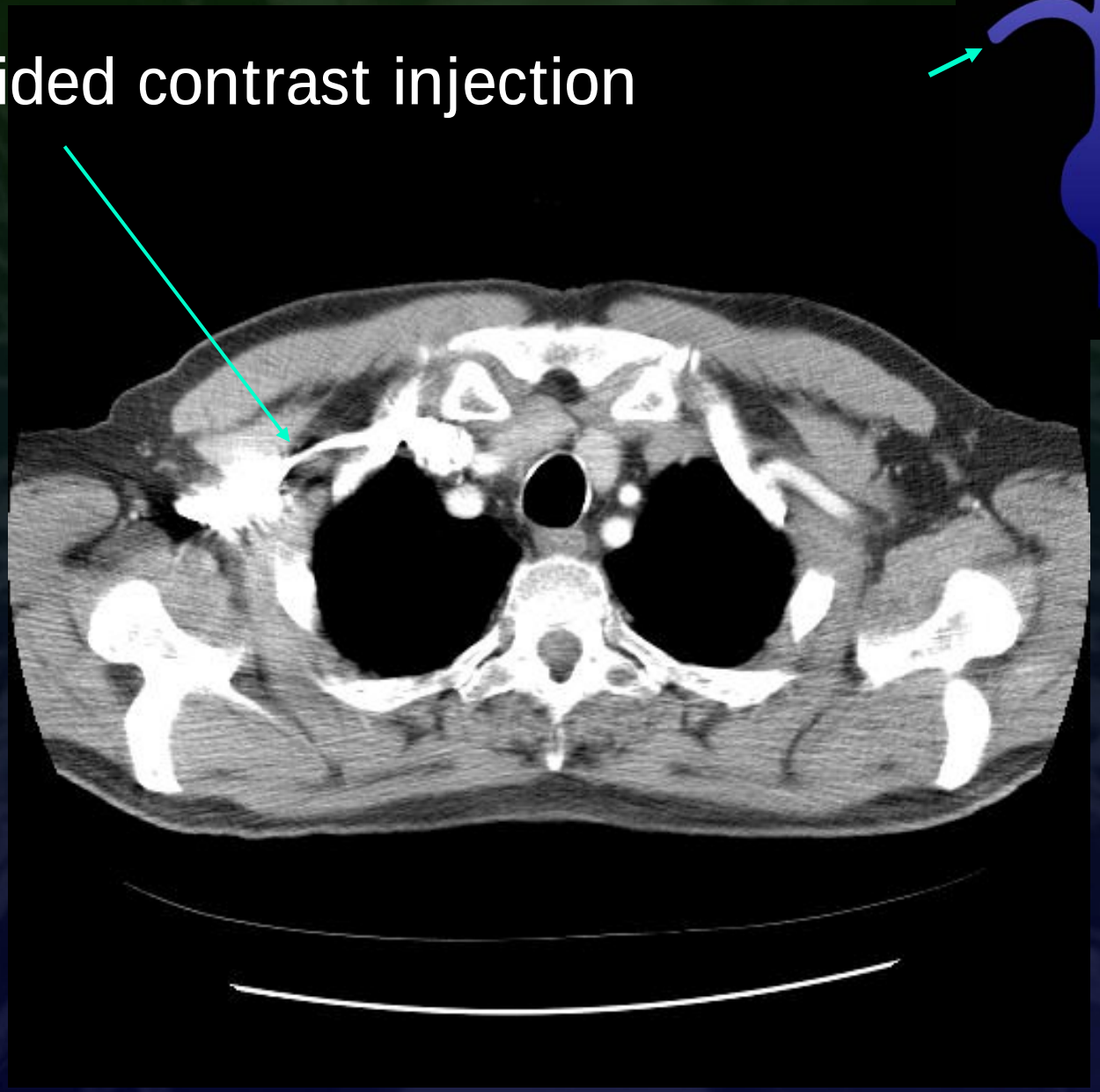
Iodinated contrast is given intravenously for diagnostic CT.

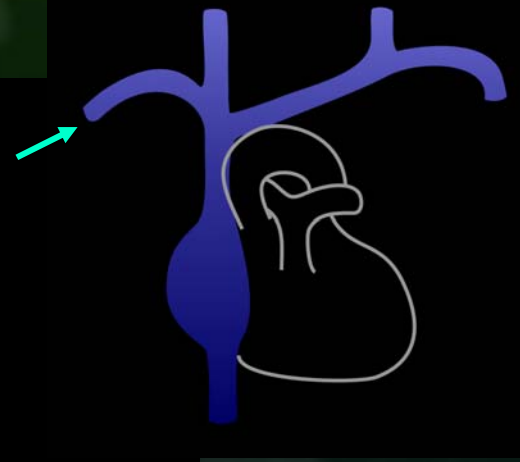
In the chest, this results in opacification (“enhancement”) of vascular structures and cardiac chambers.

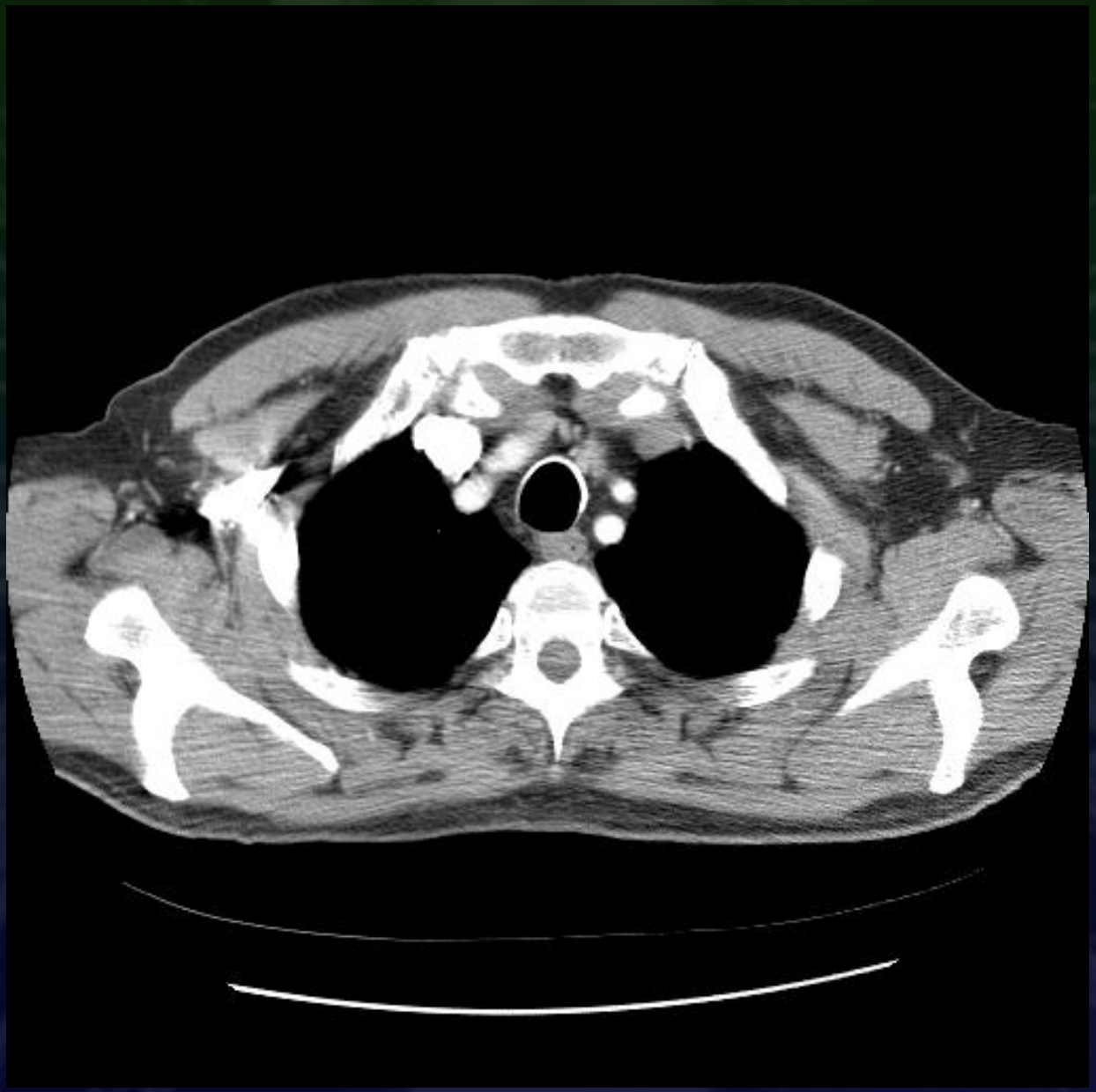


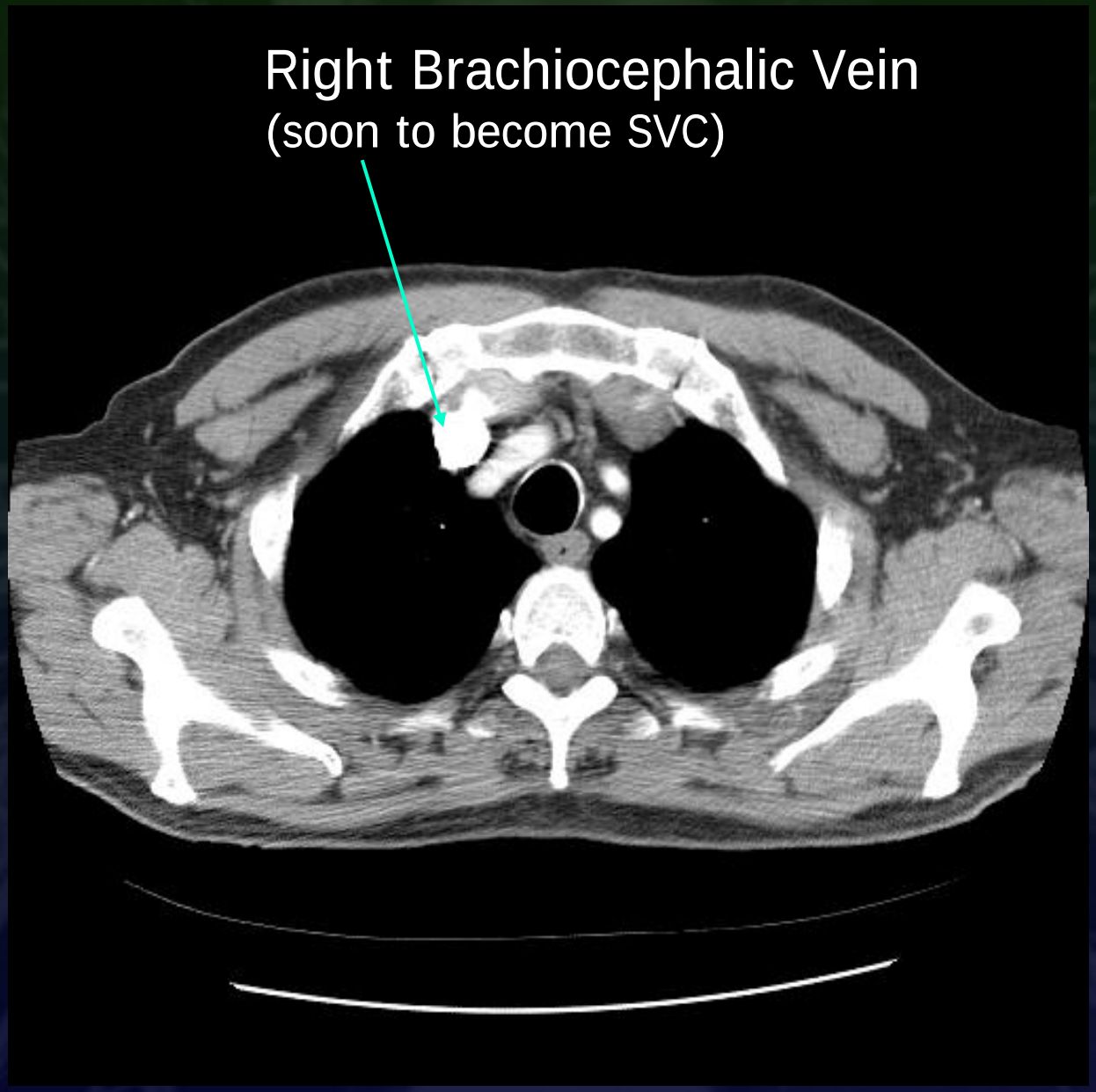


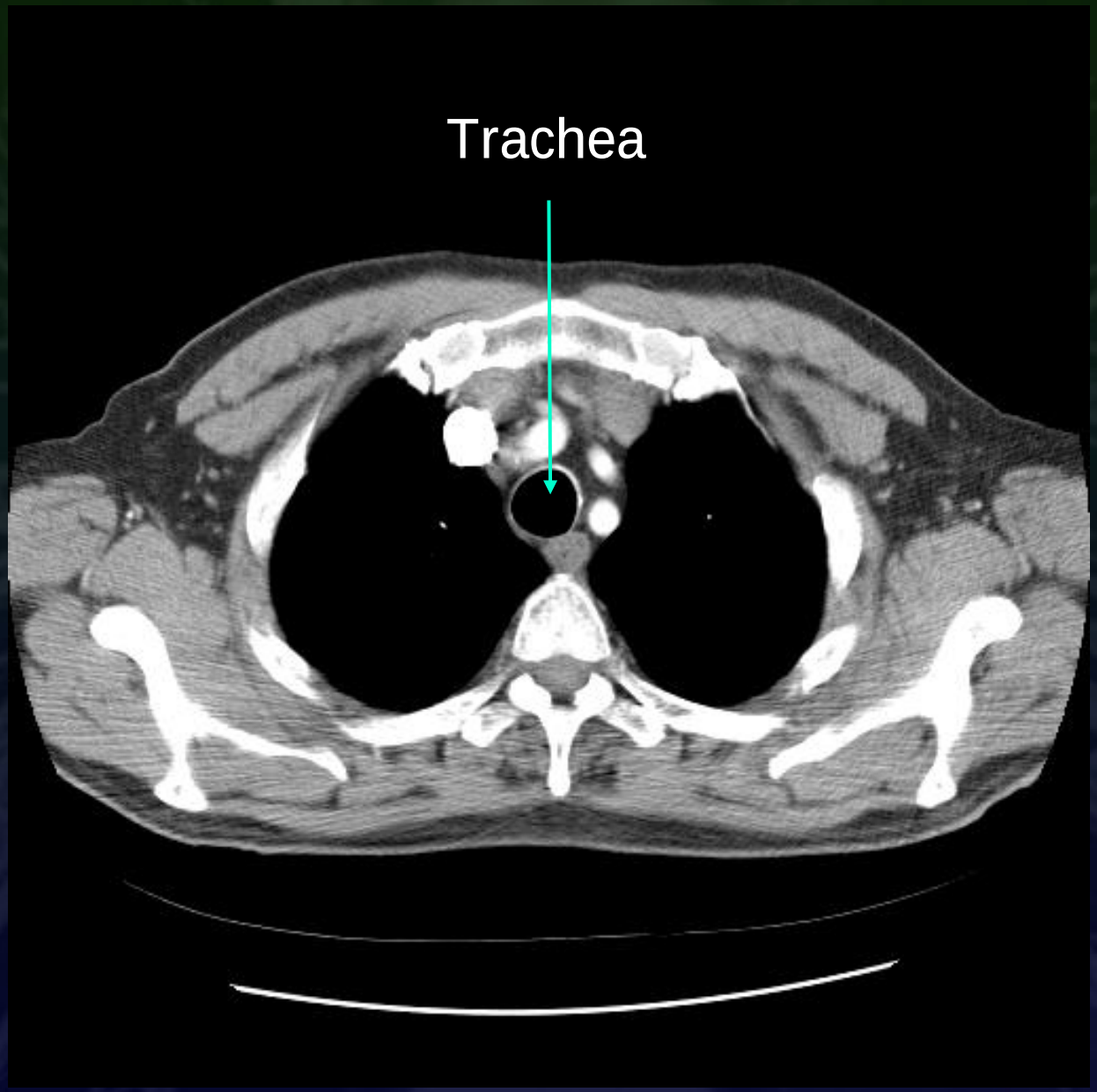
Rt sided contrast injection

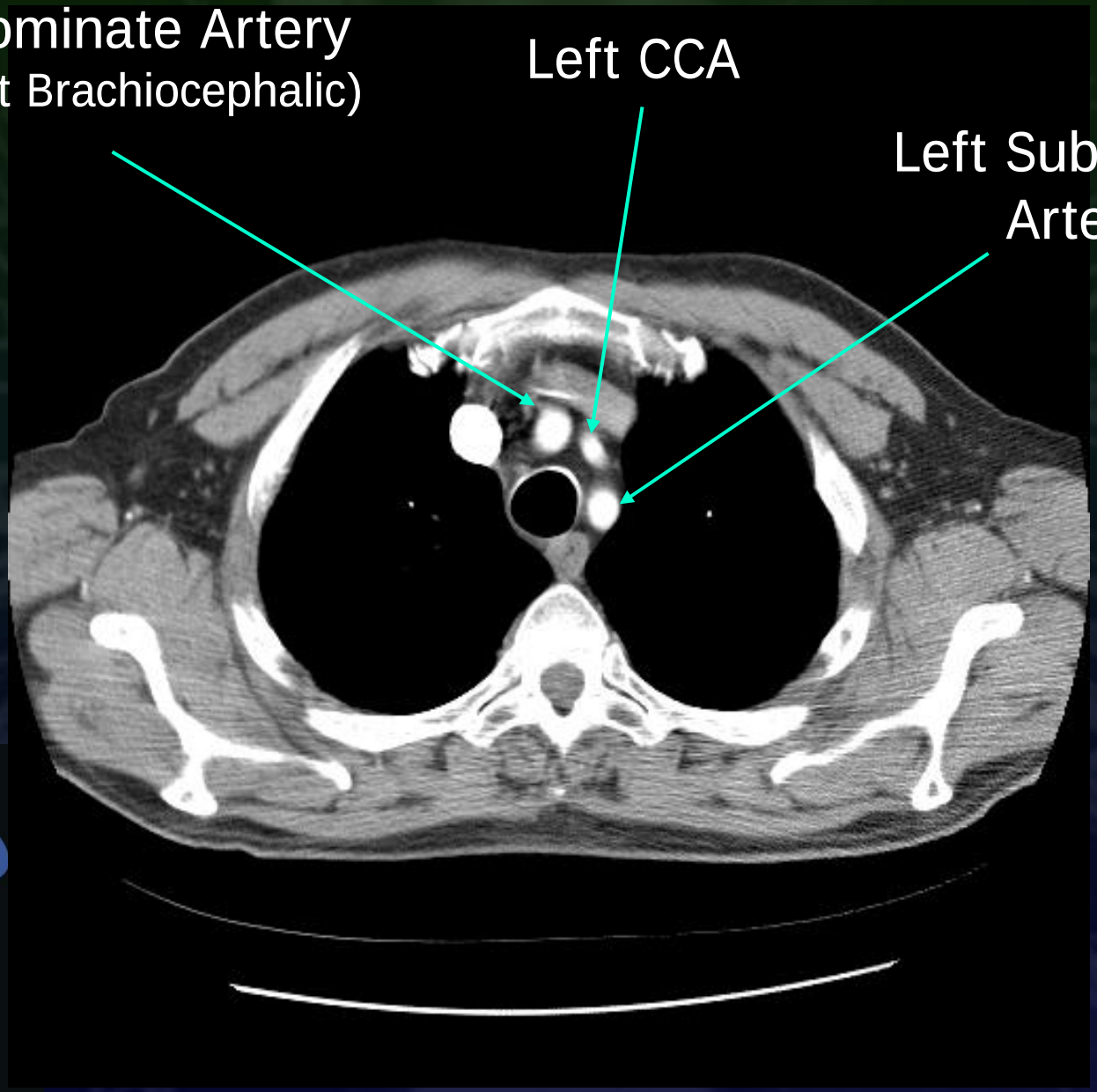




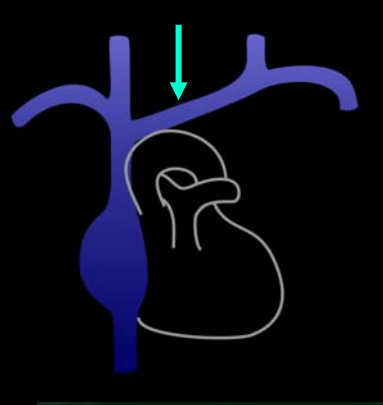


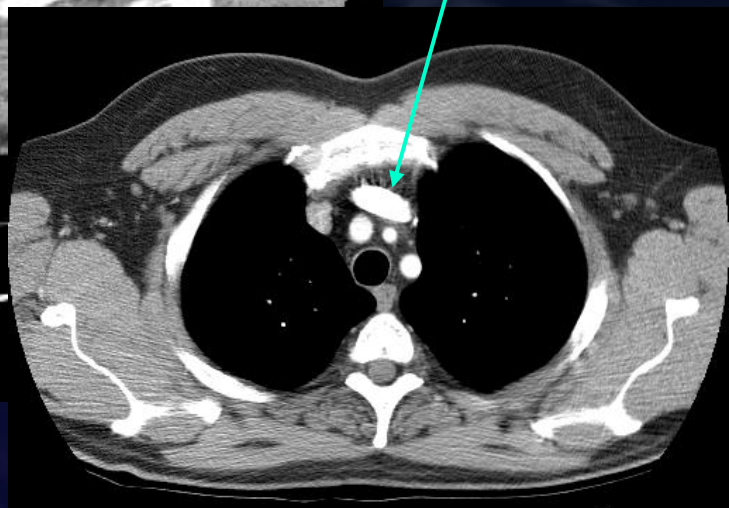

Right Brachiocephalic Vein
(soon to become SVC)

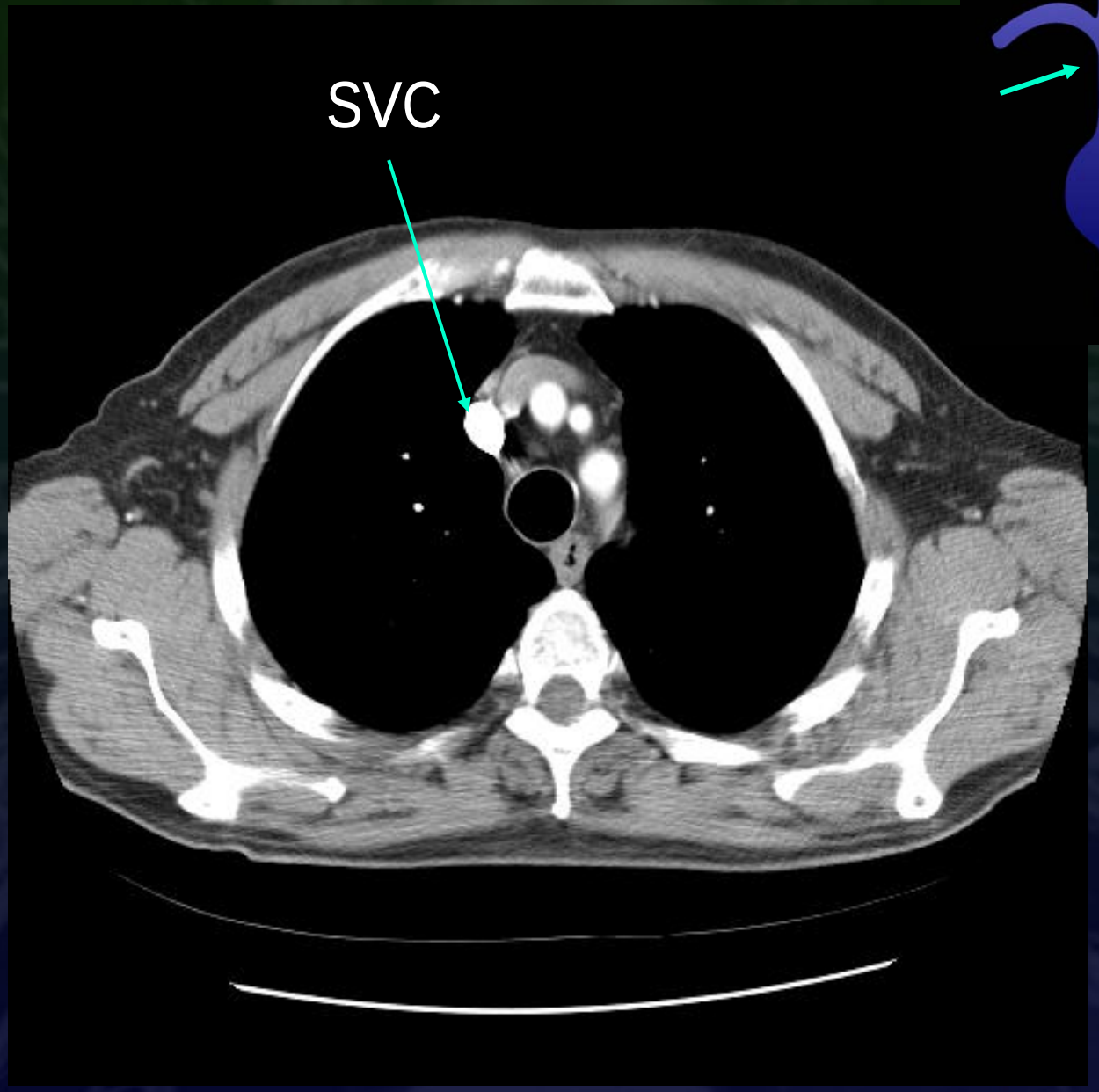

Trachea

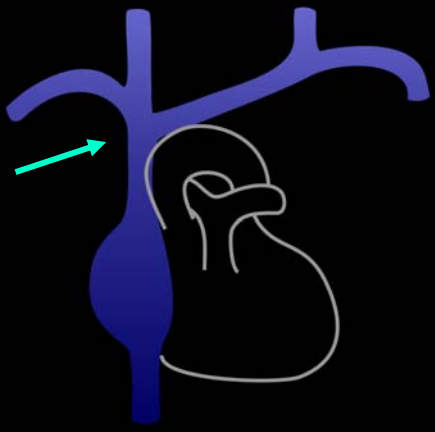

Innominate Artery
(Right Brachiocephalic)
Left CCA
Left Subclavian
Artery

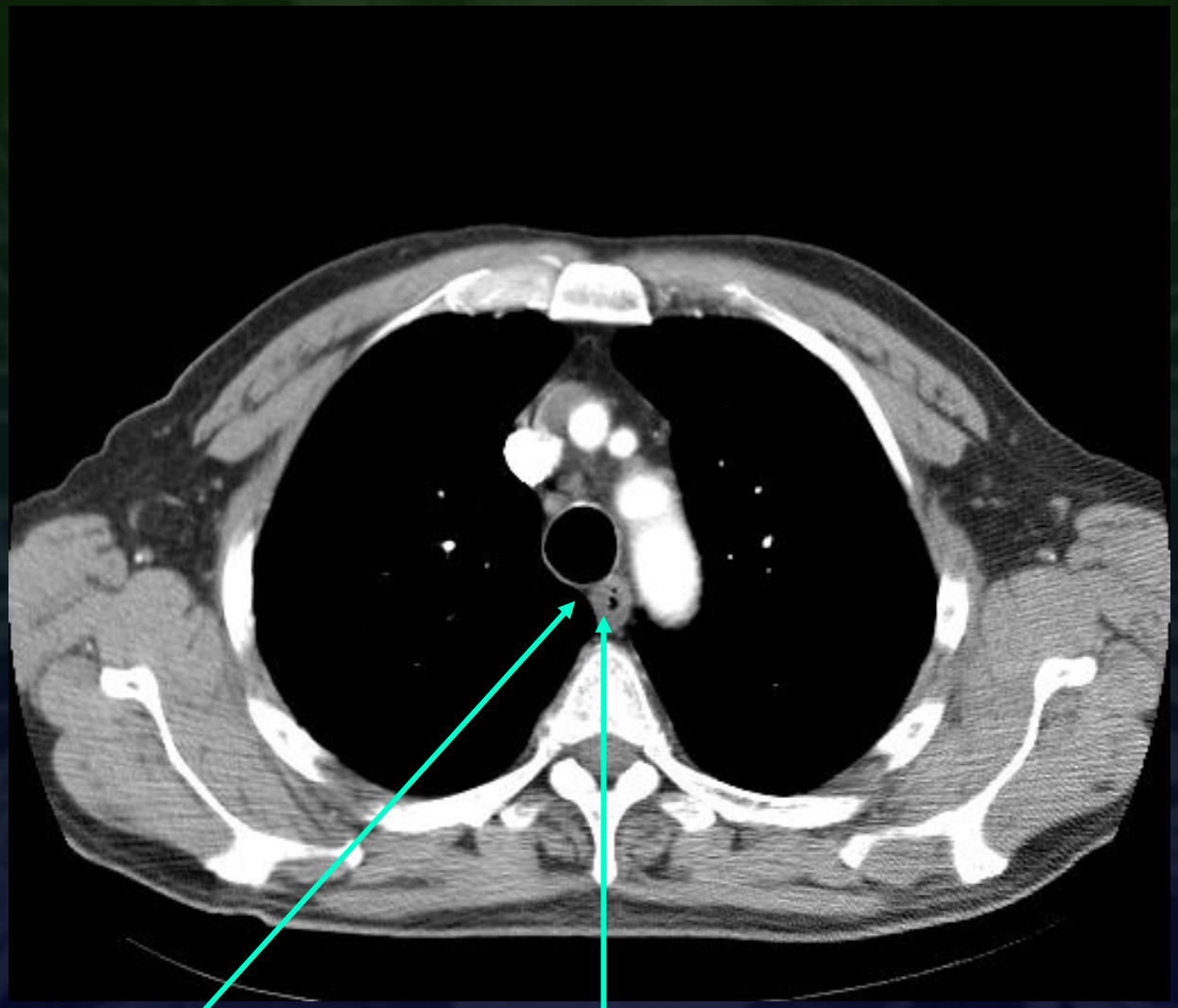
Left Brachiocephalic Vein
(anterior retrosternal location)

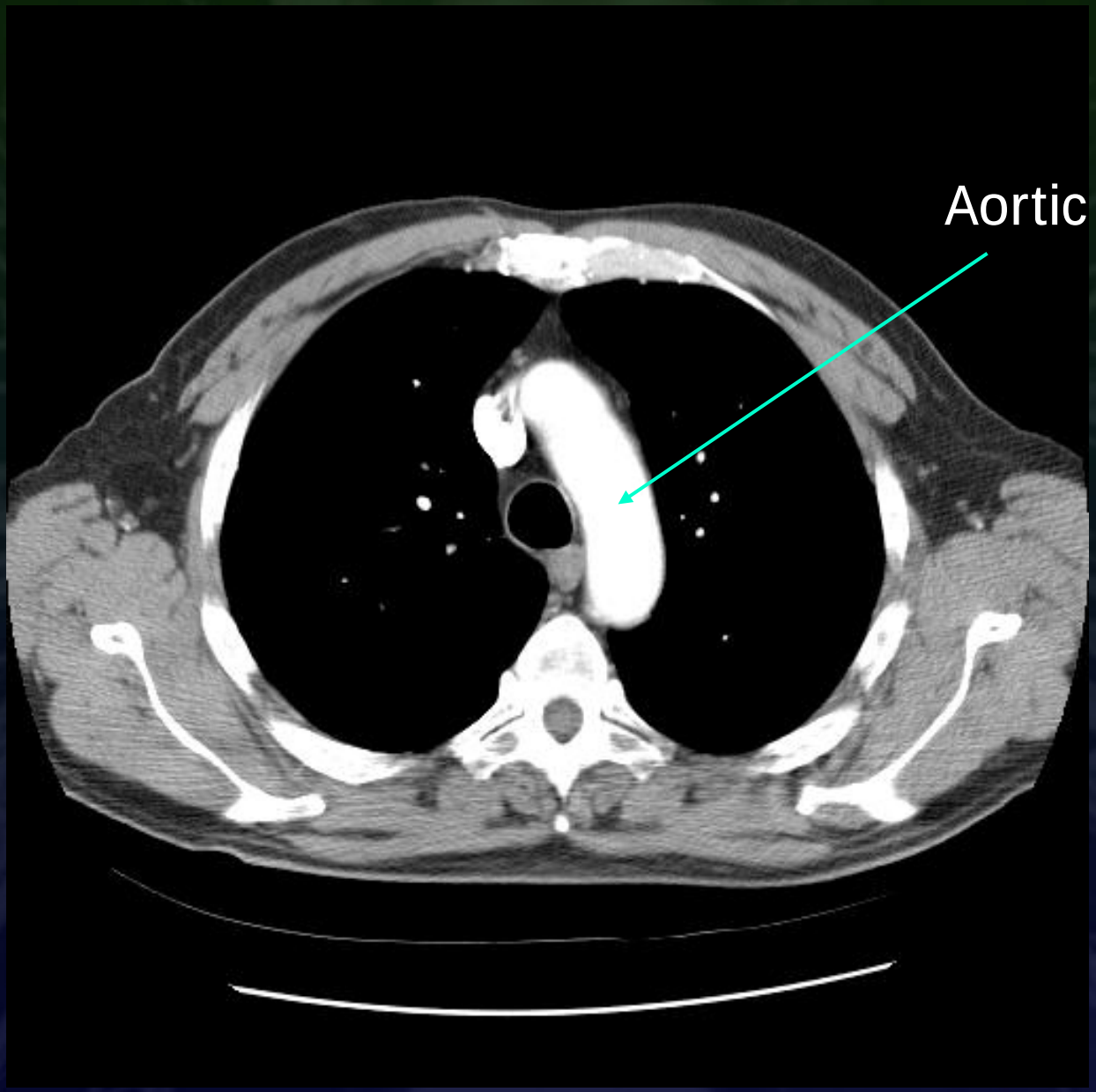


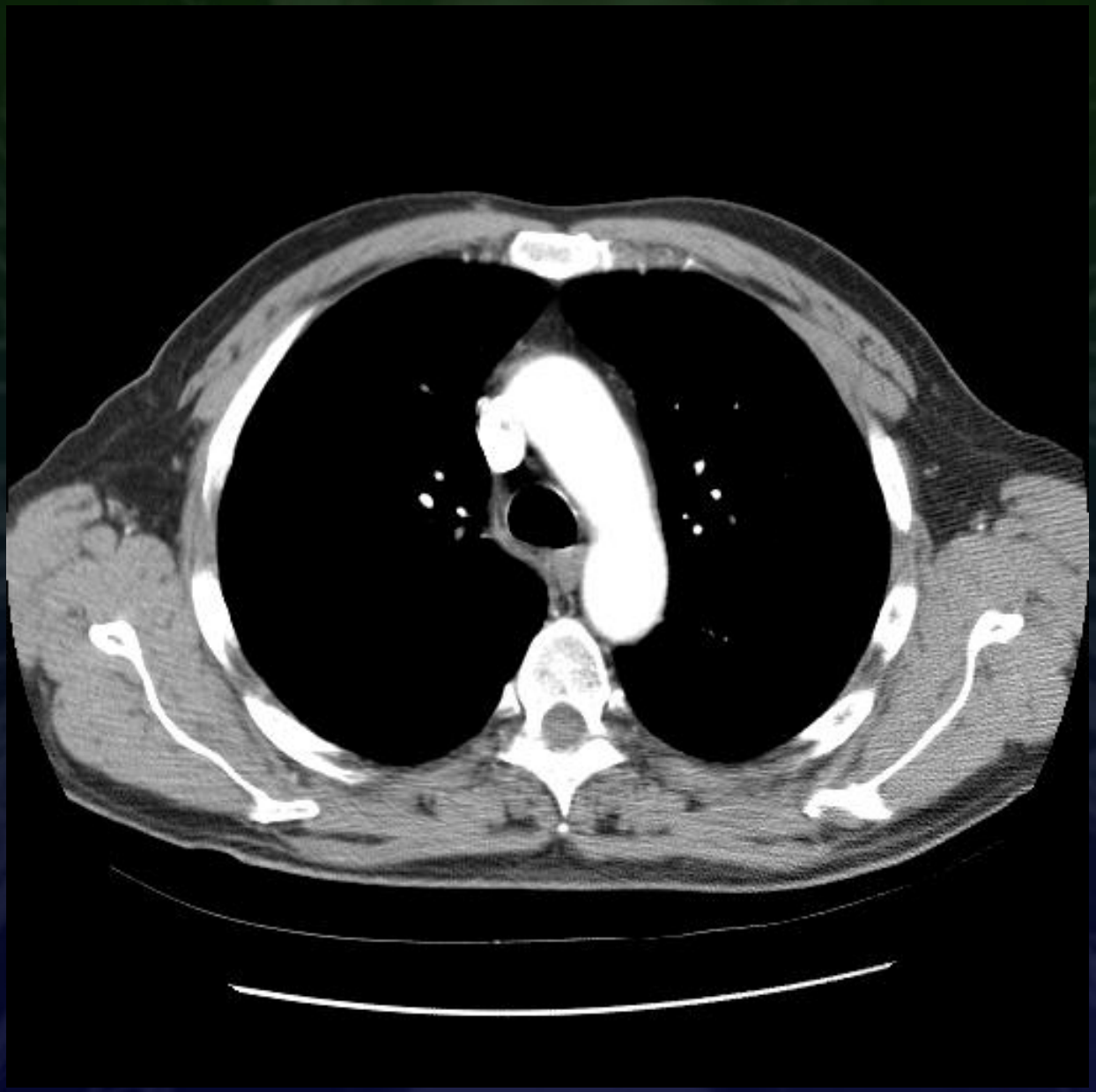


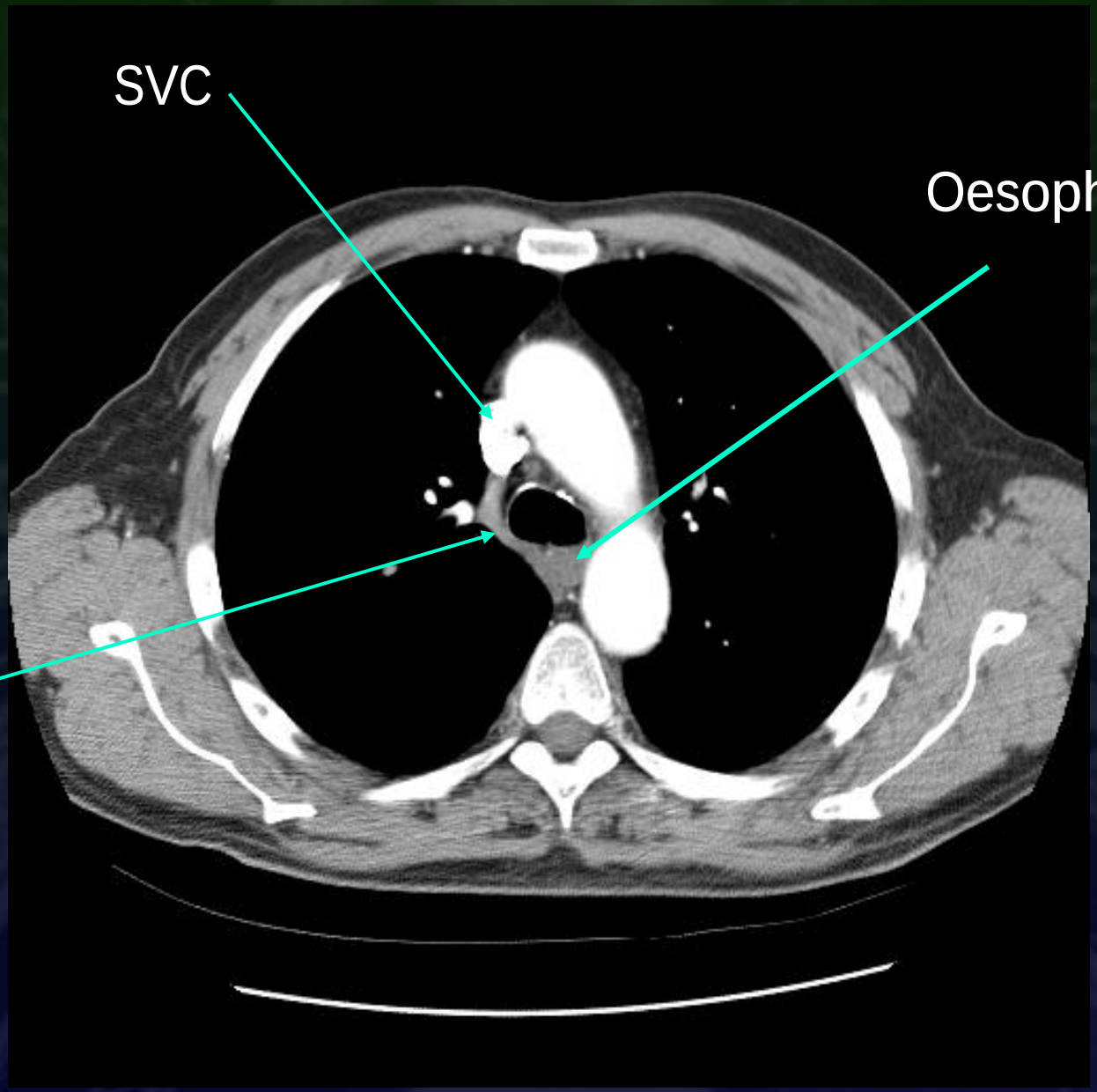

SVC

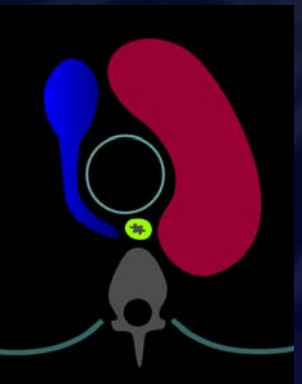


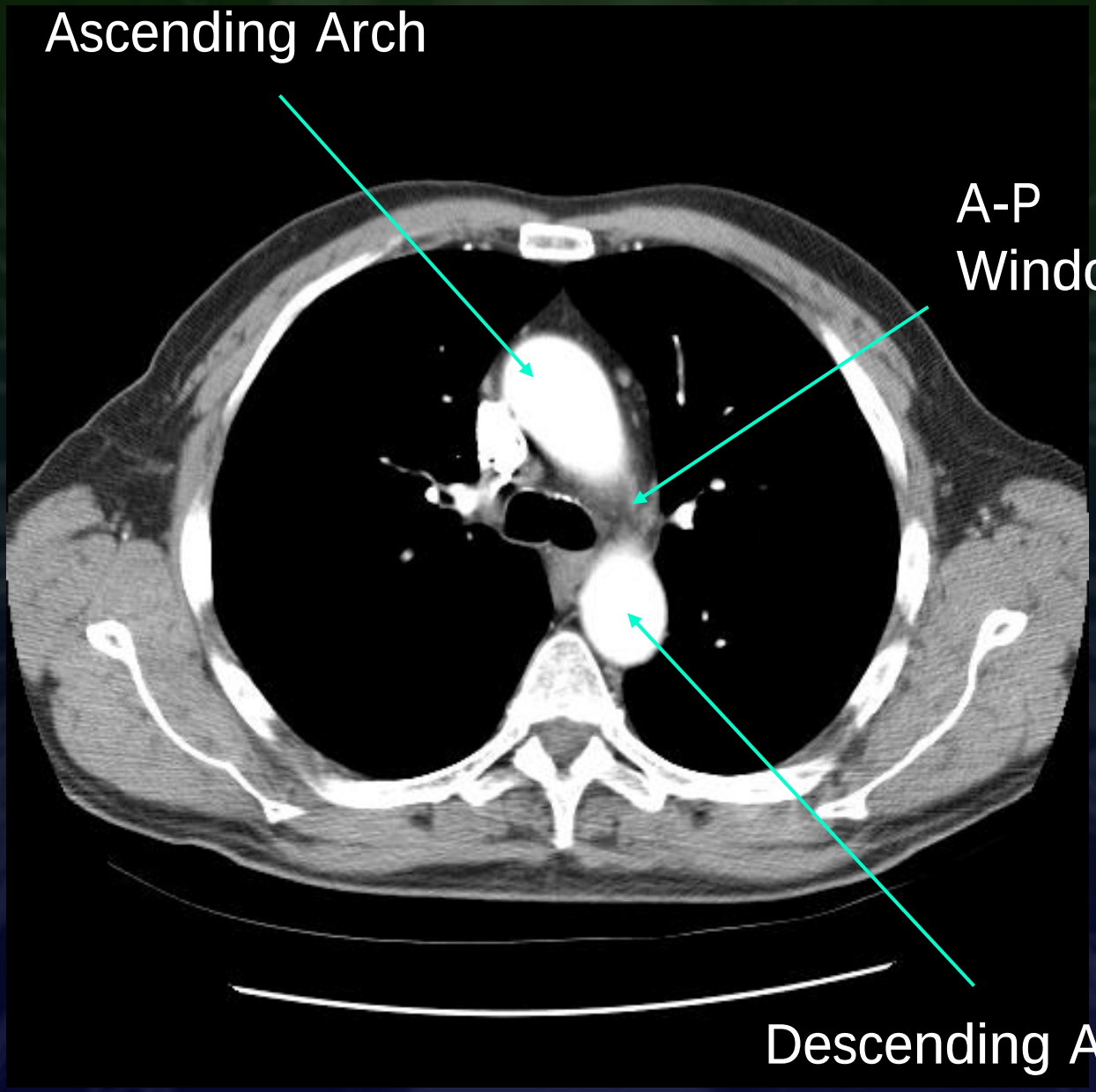

Tracheo-oesophageal Groove
Oesophagus

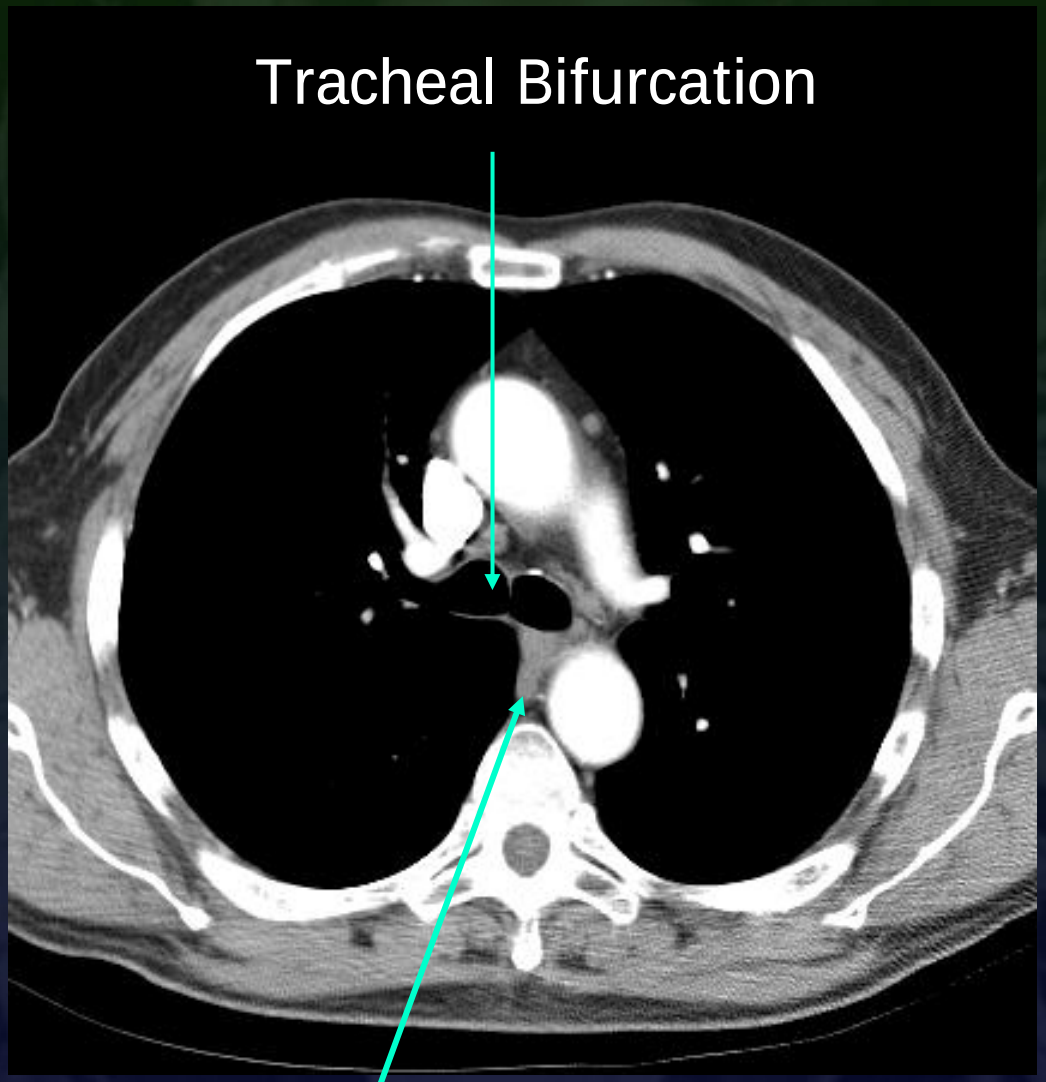

Aortic Arch

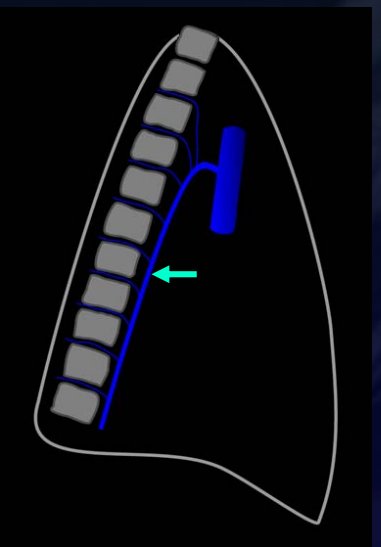



SVC
Oesophagus
Azygos
Vein

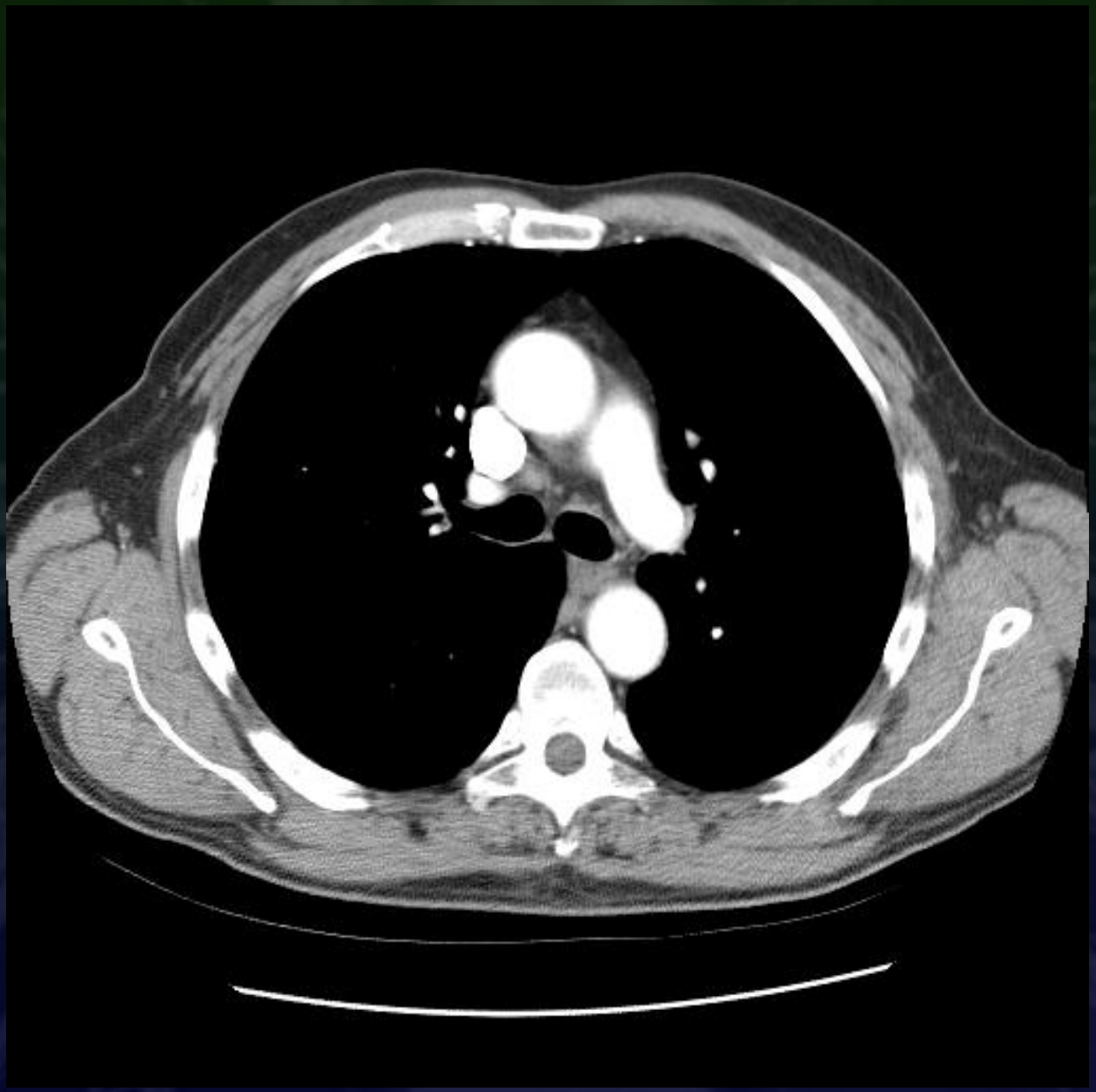



Ascending Arch
A-P
Window
Descending Arch

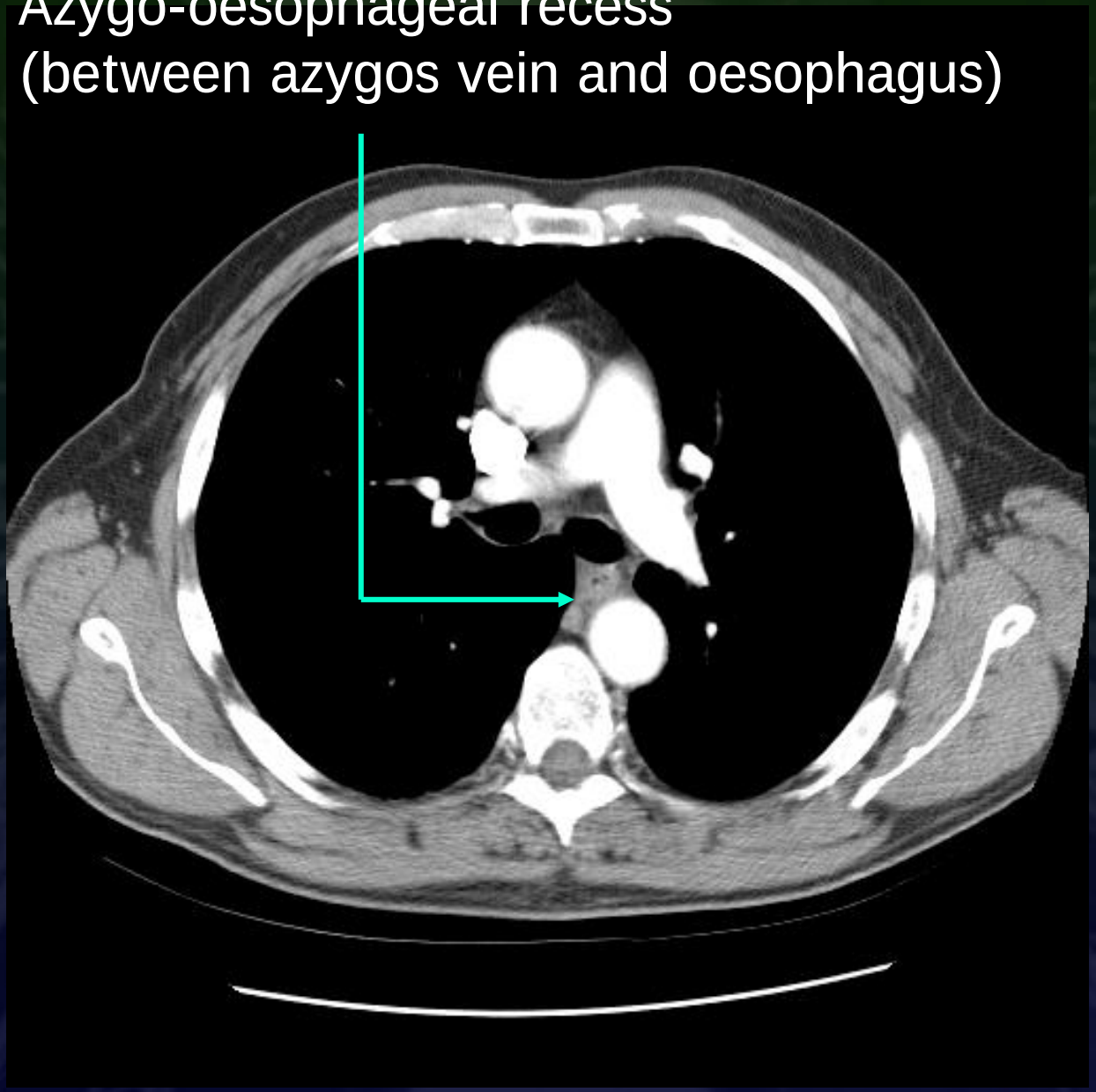


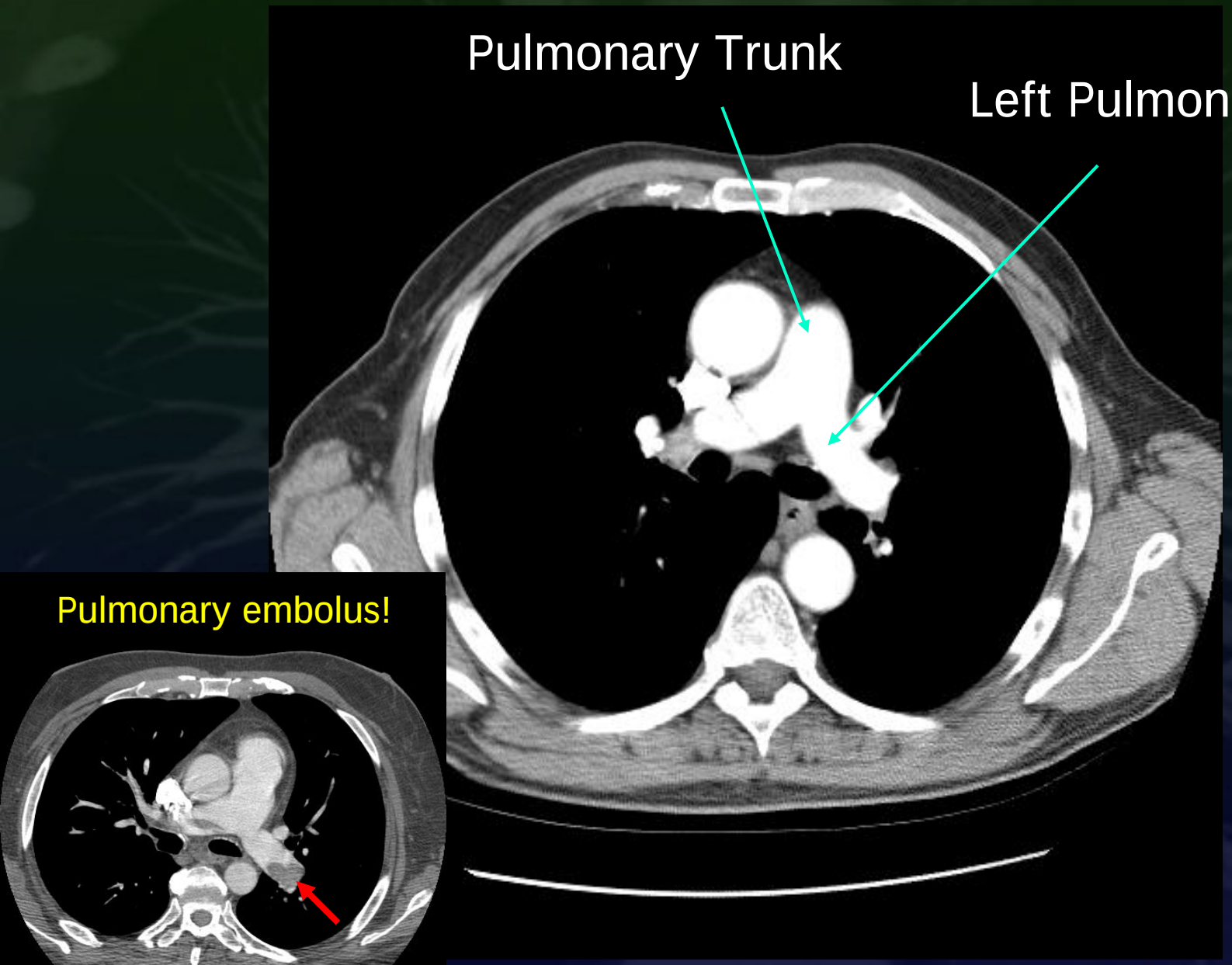


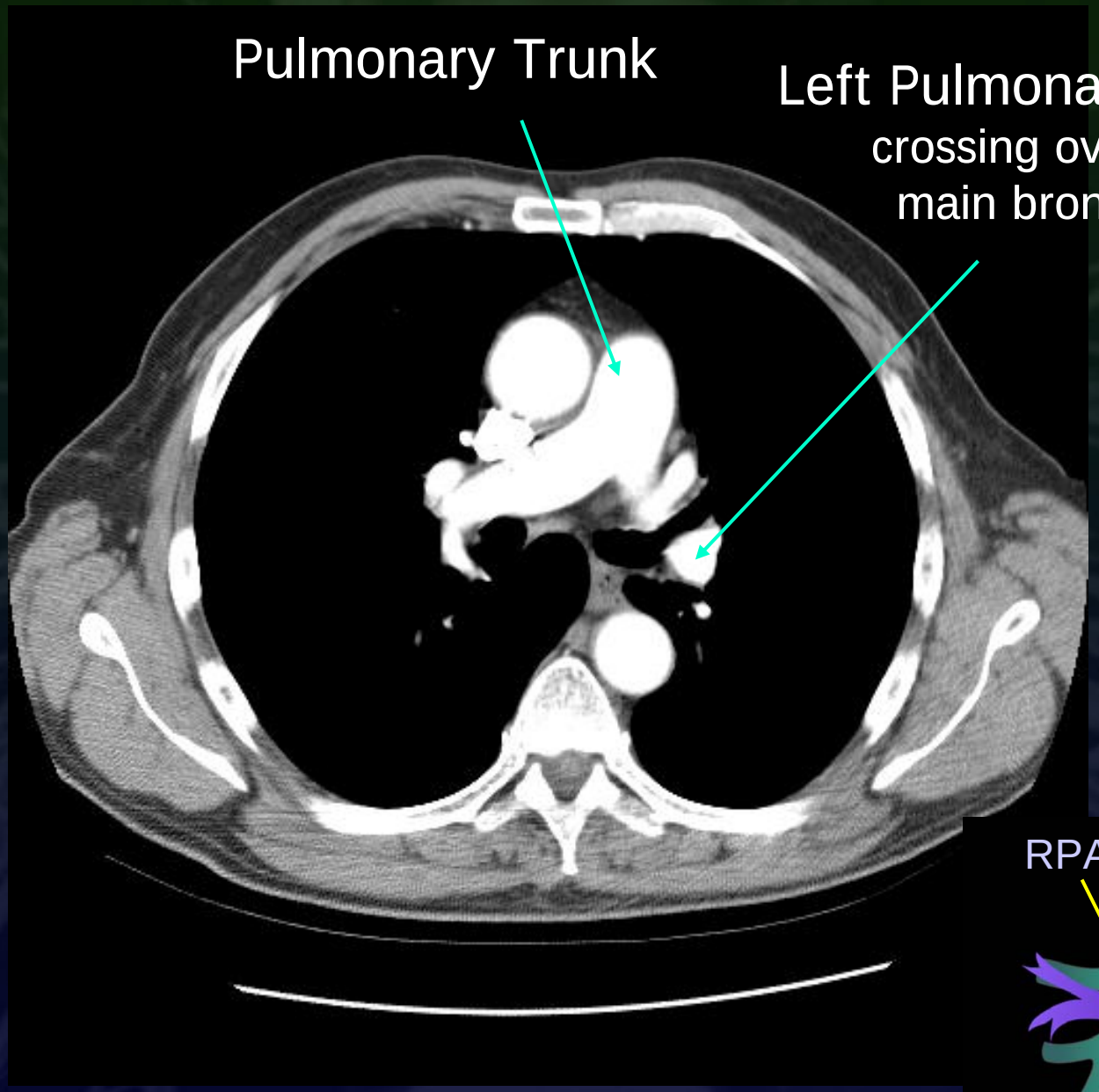
Azygos vein (vertical segment)
in posterior mediastinum

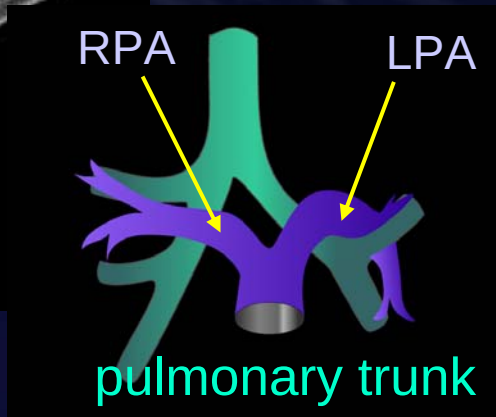


Azygo-oesophageal recess
(between azygos vein and oesophagus)

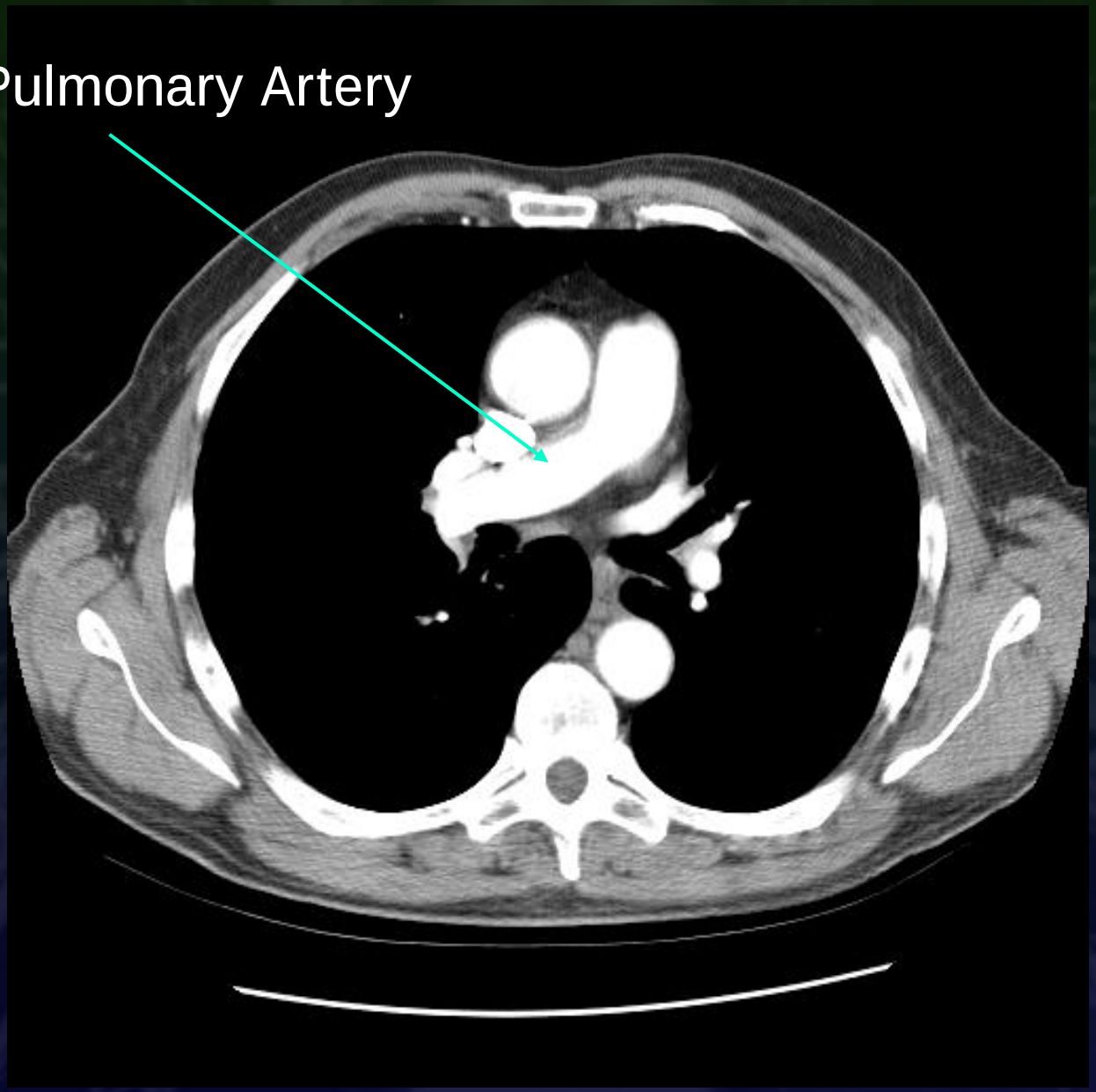


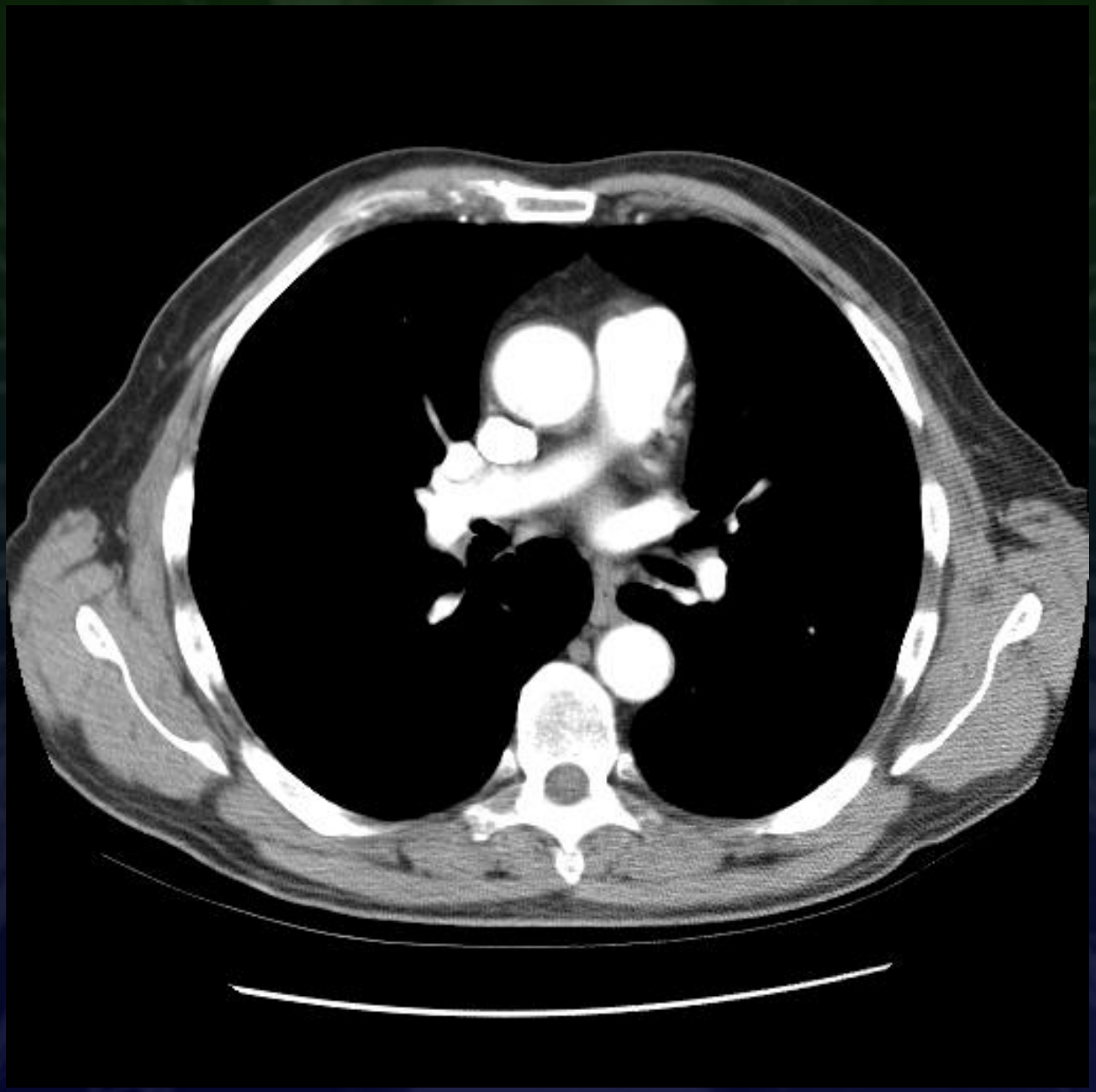

Pulmonary Trunk
Left Pulmonary Artery
Pulmonary embolus!


Pulmonary Trunk
Left Pulmonary Artery
crossing over left
main bronchus

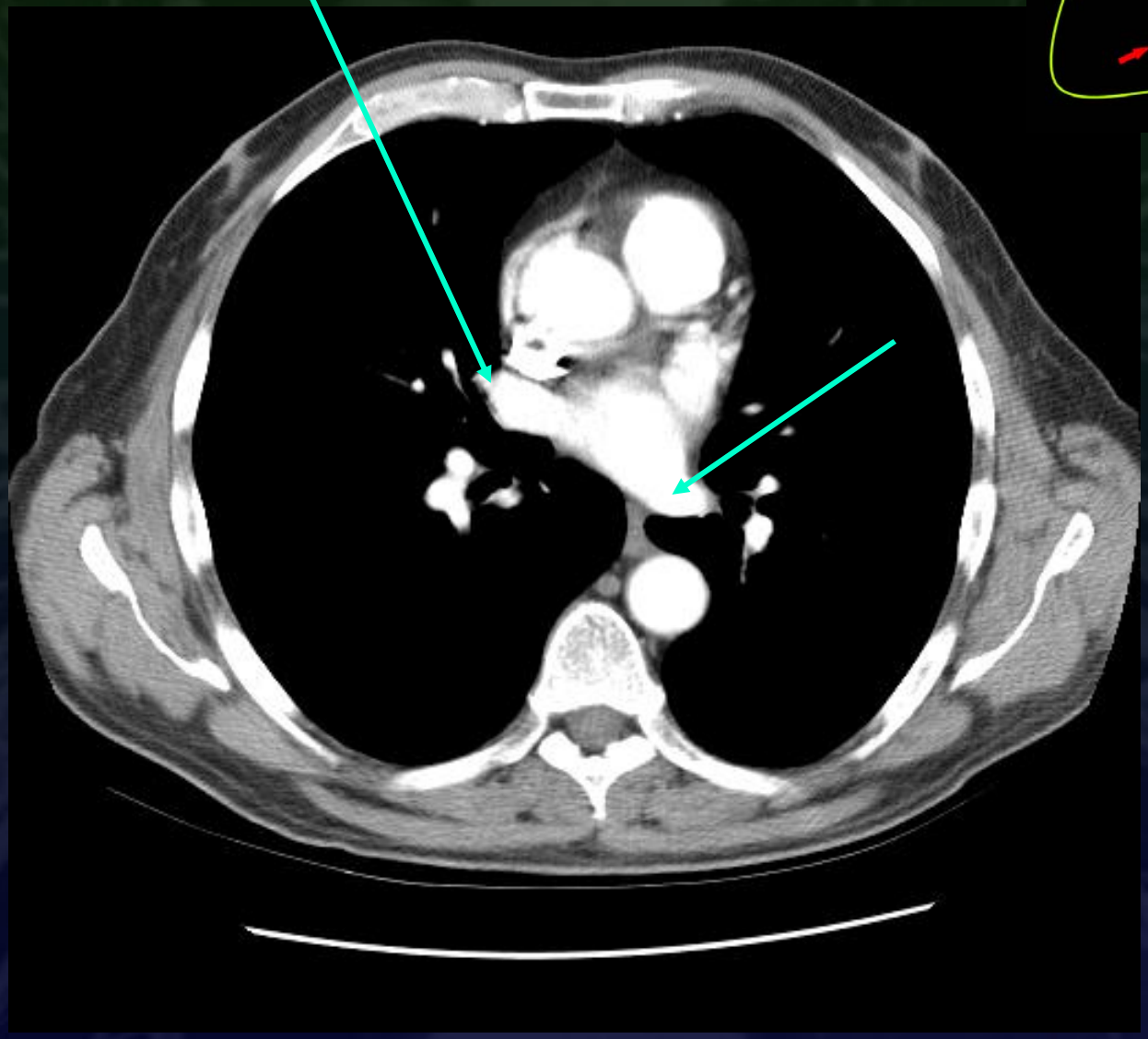

RPA
LPA
pulmonary trunk

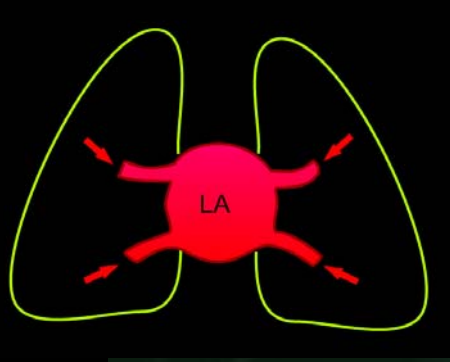
Right Pulmonary Artery

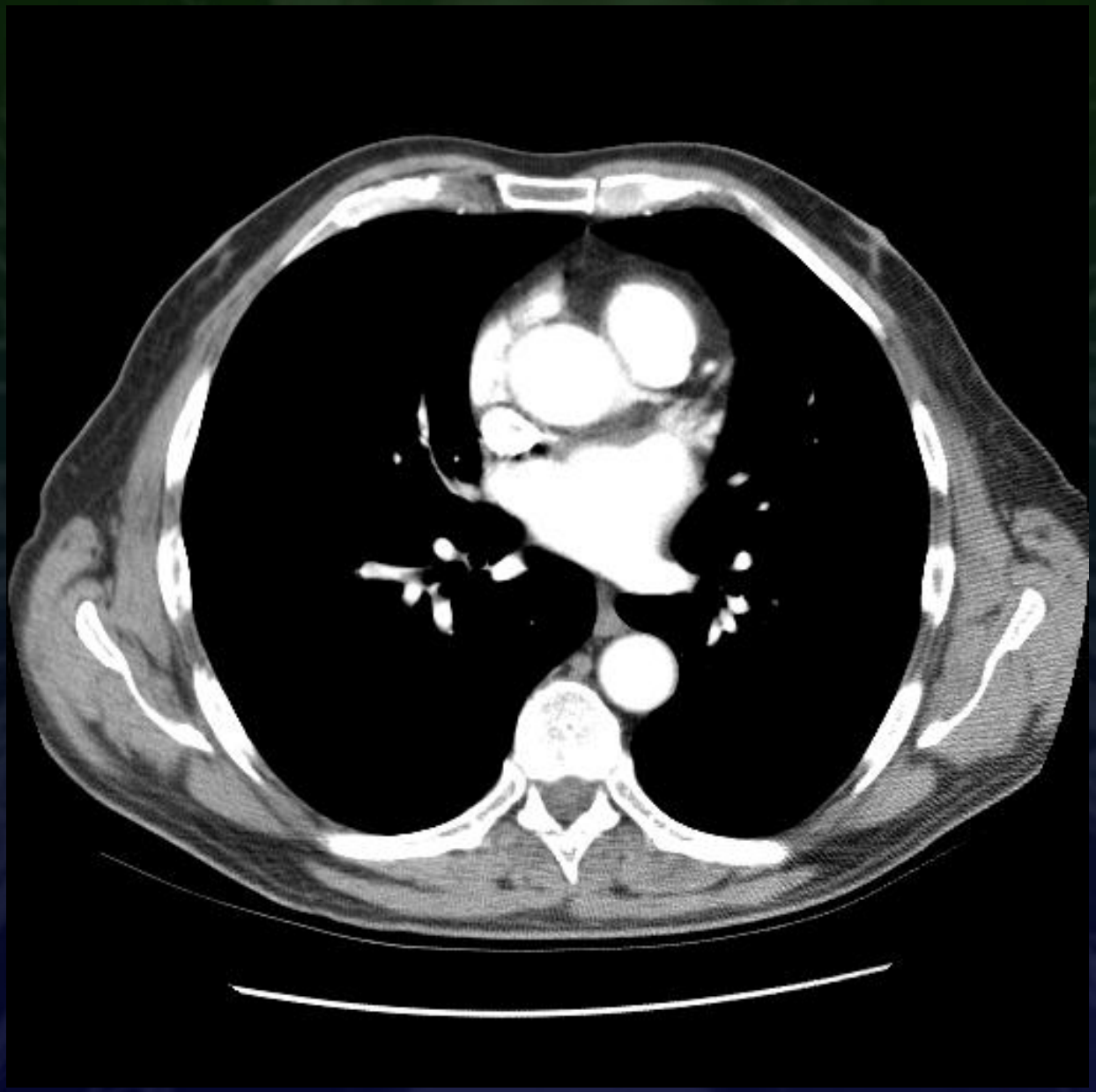


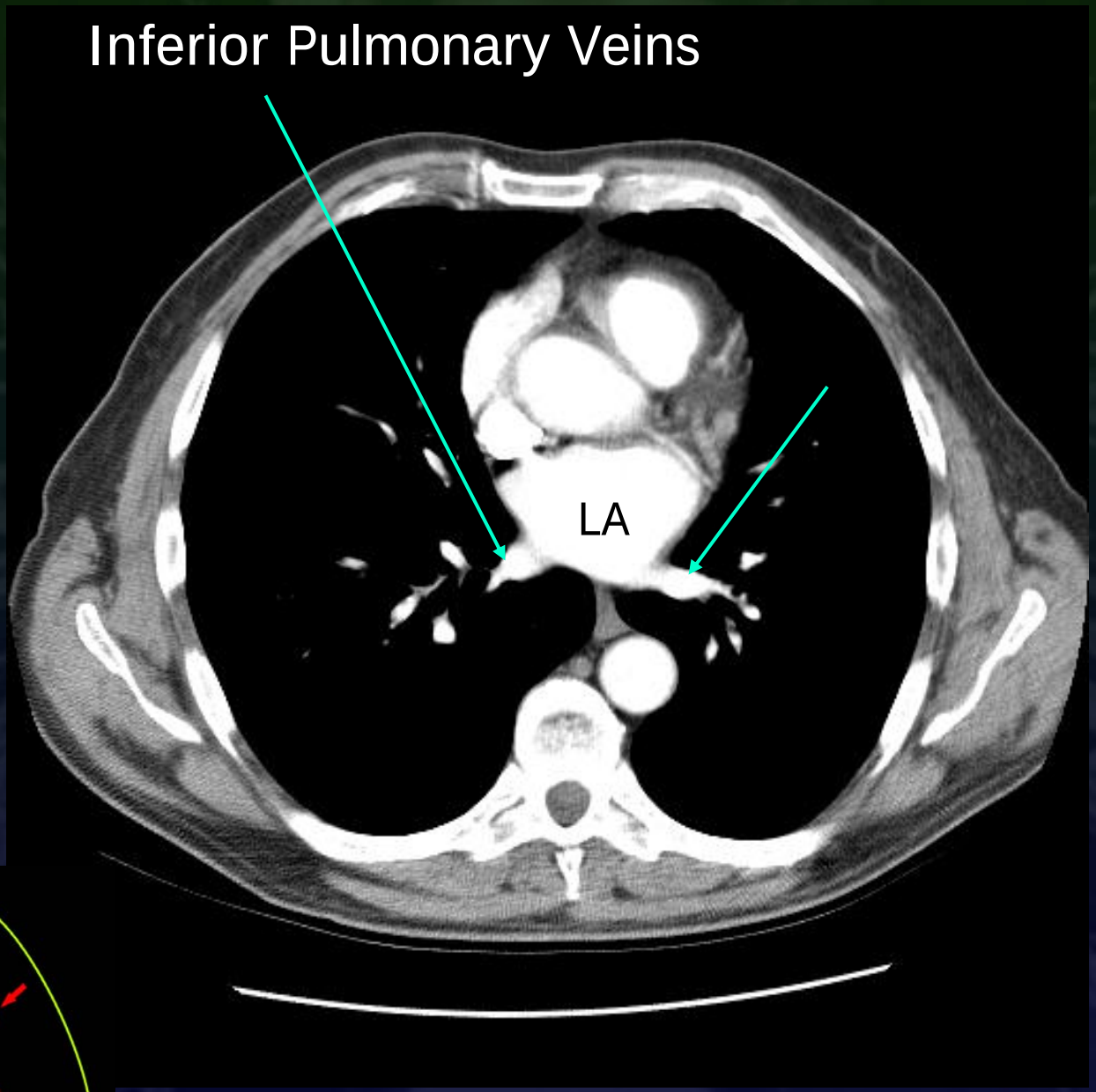


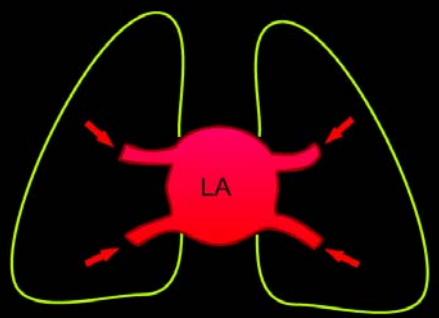
Superior Pulmonary Veins

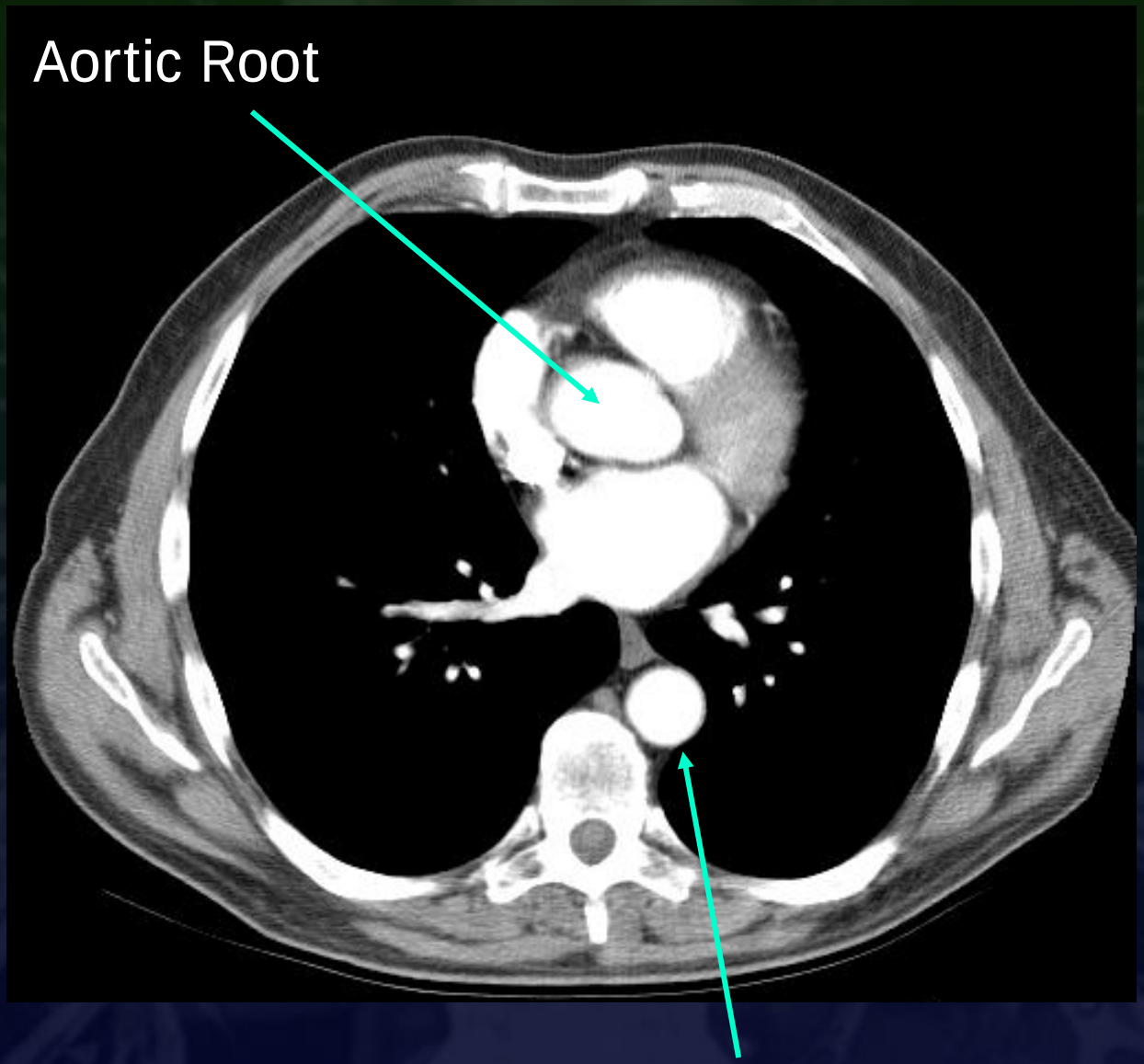


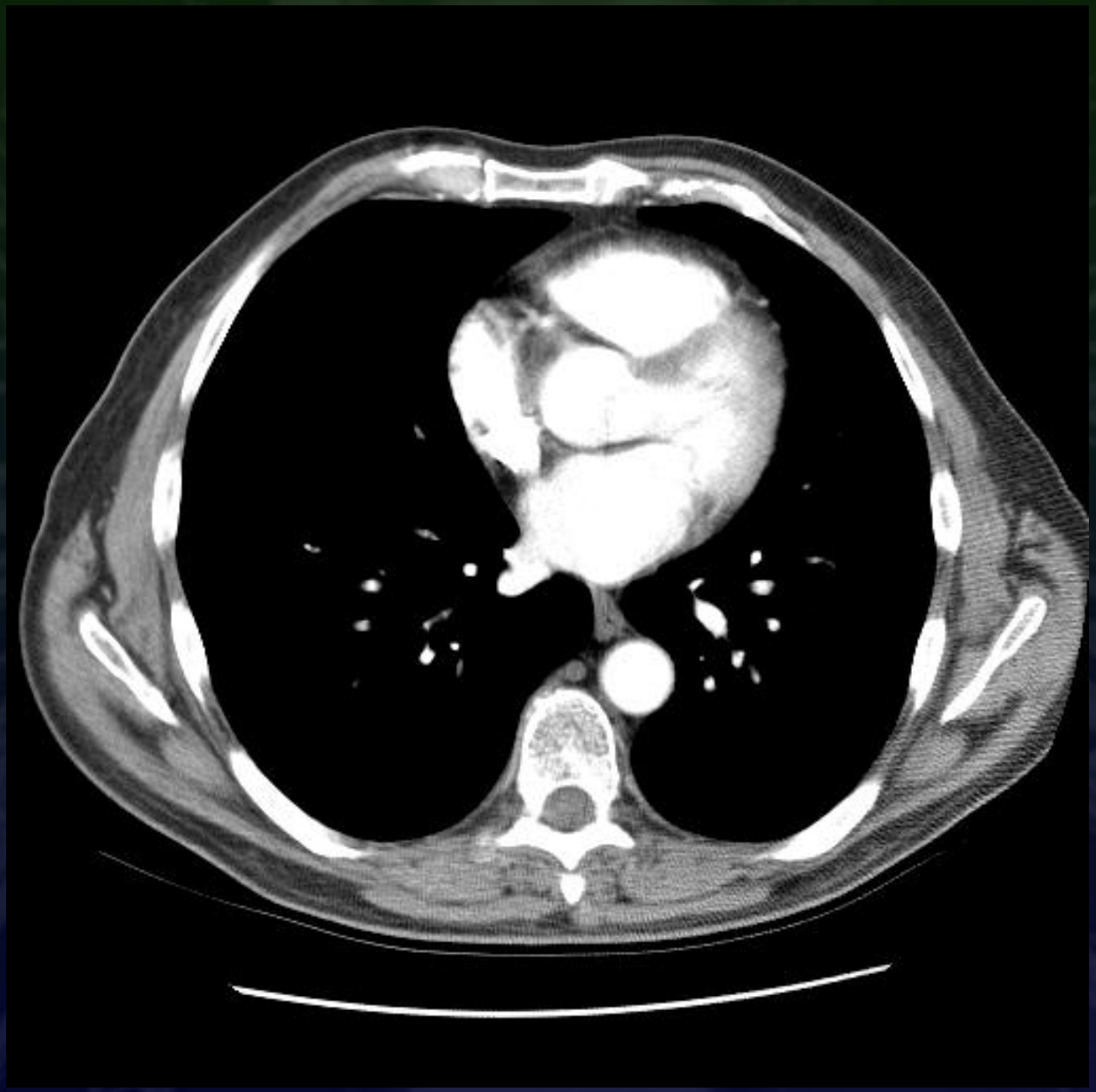


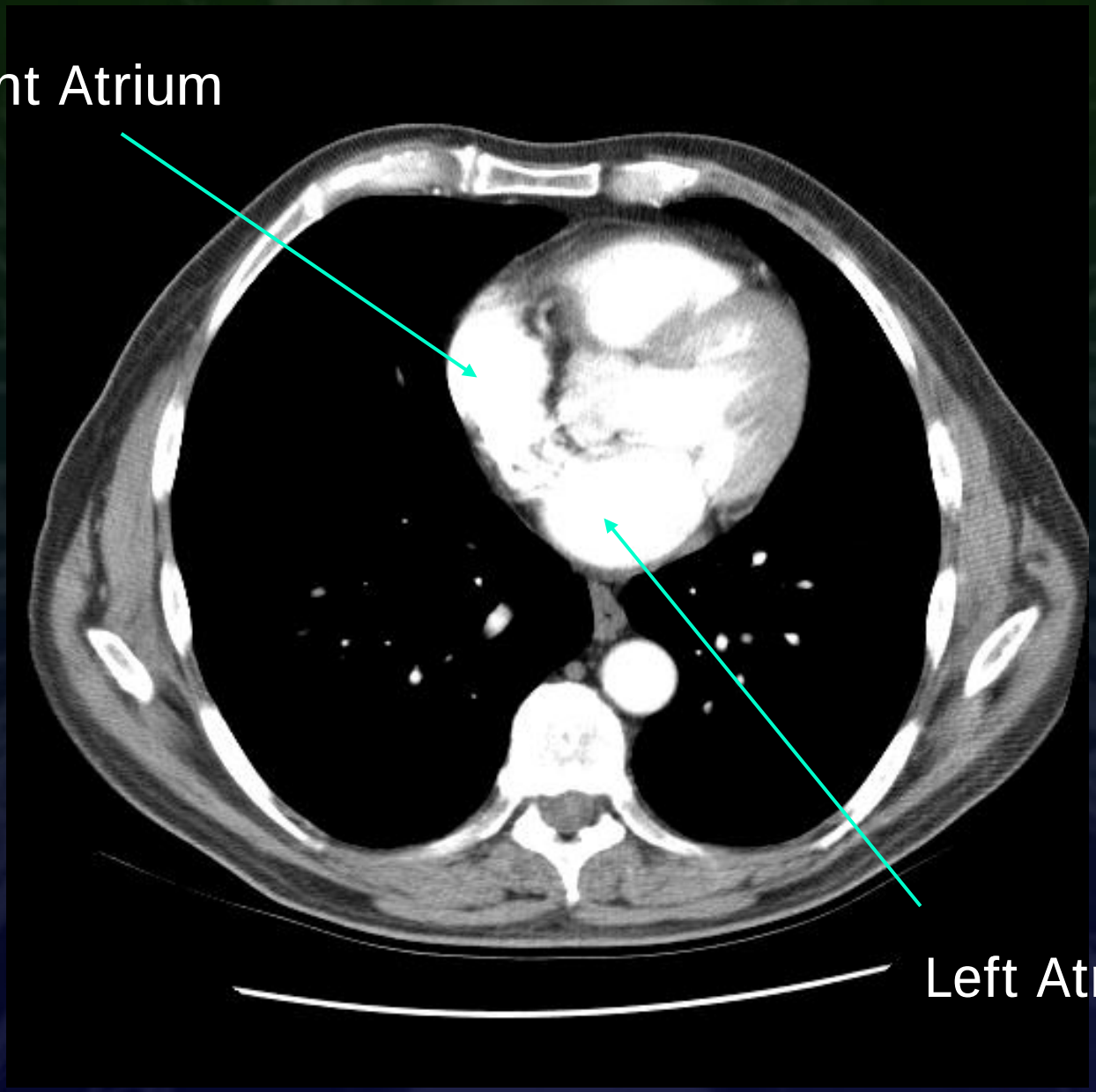


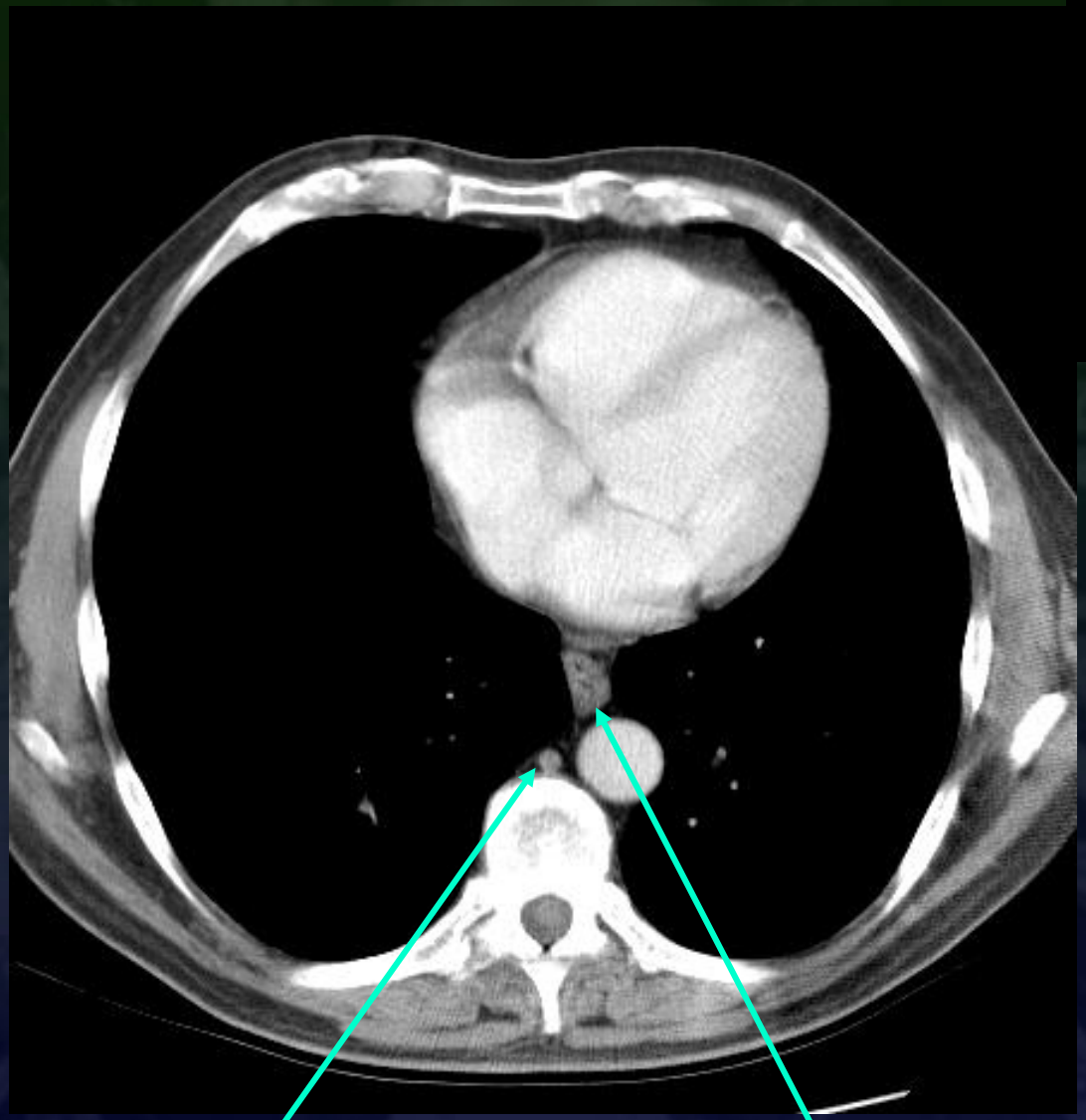

Inferior Pulmonary Veins
LA

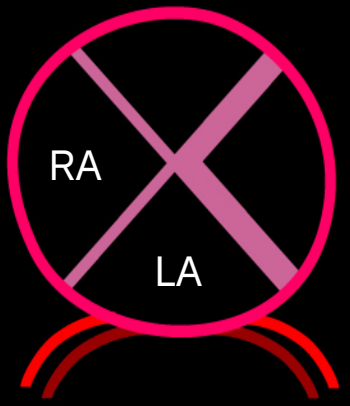

LA

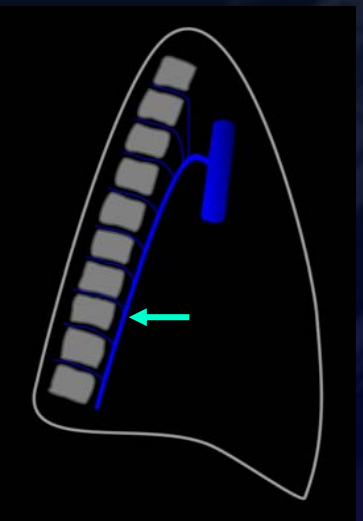

Aortic Root
Descending Thoracic Aorta

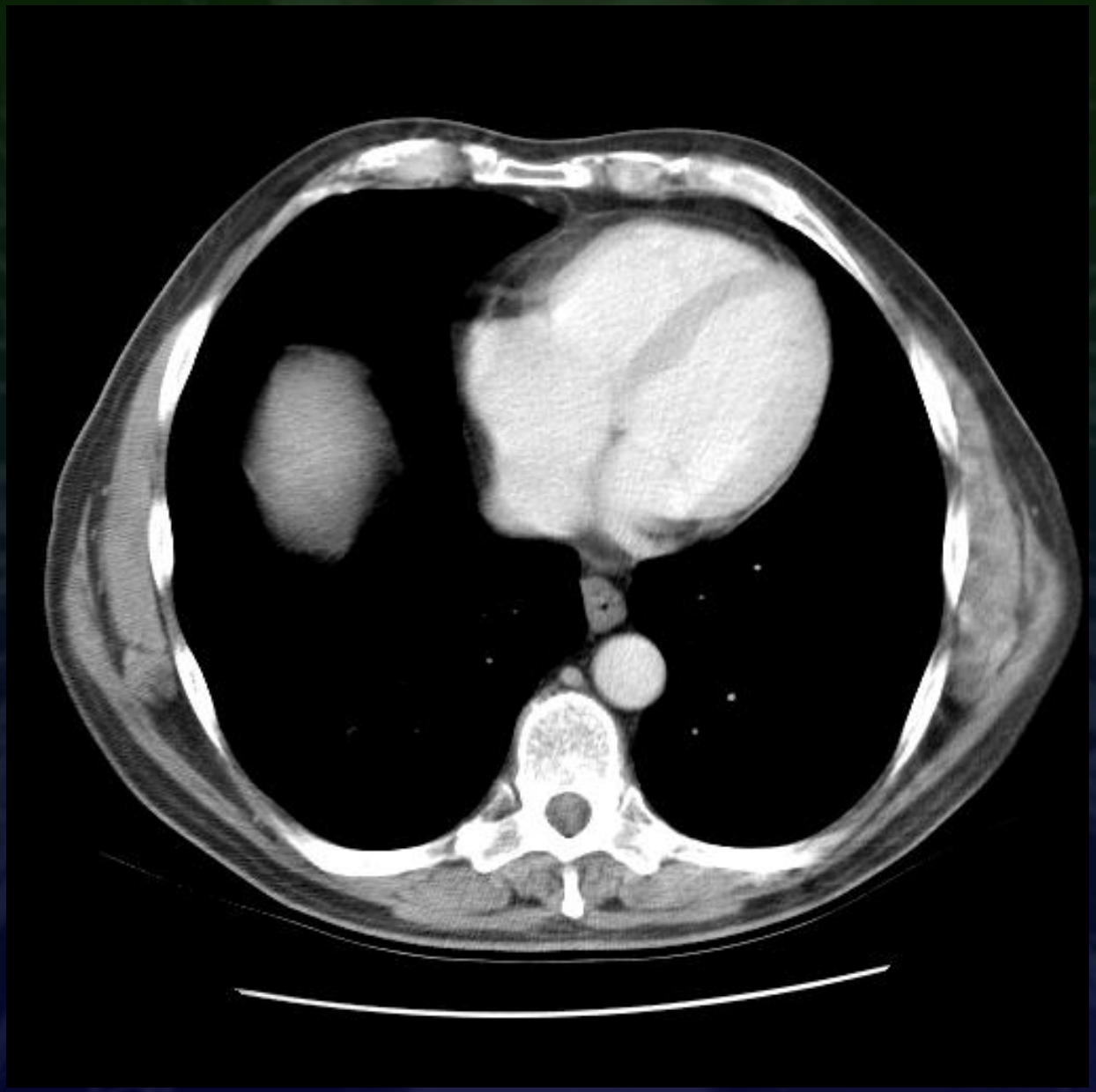


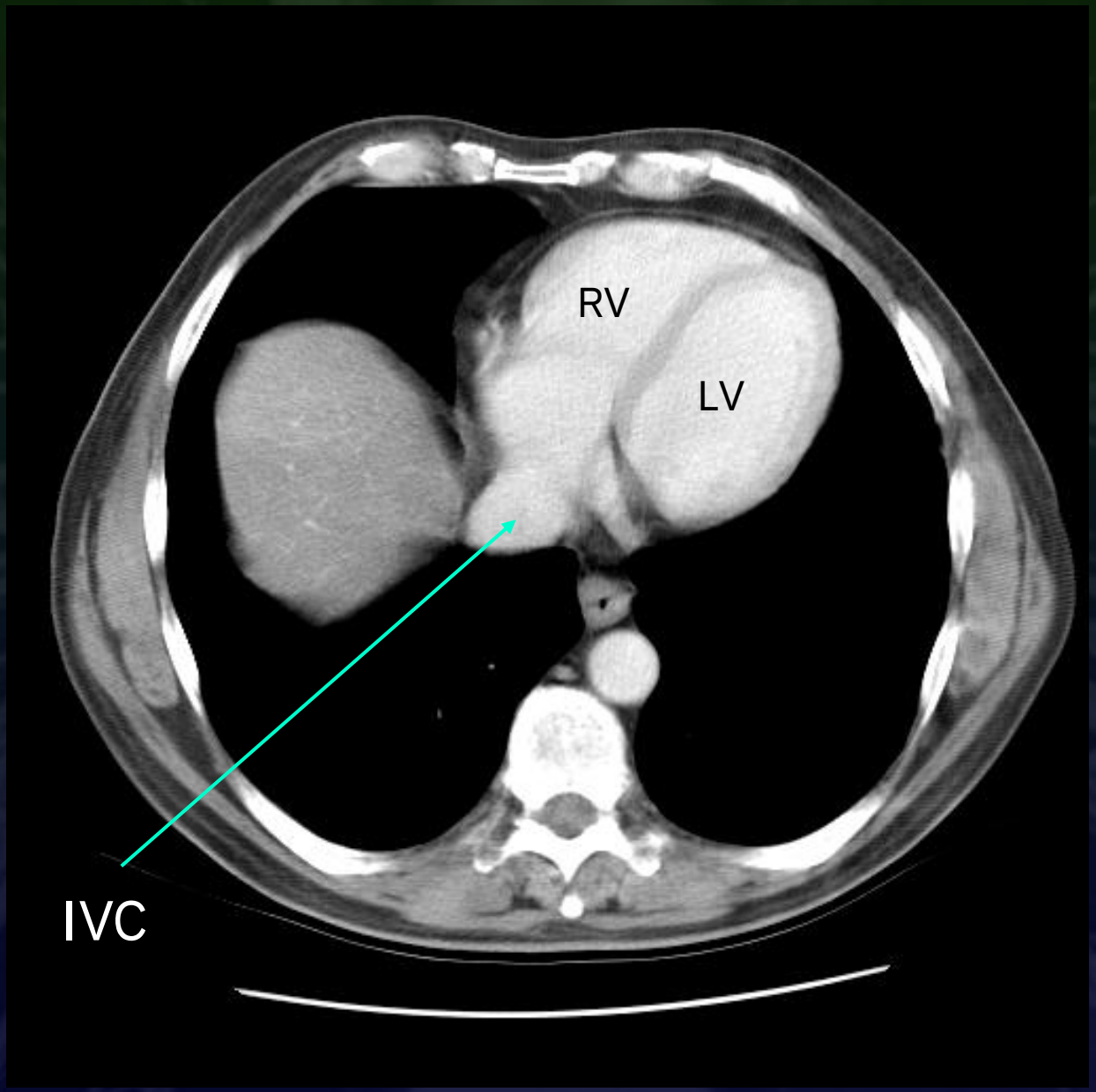

Right Atrium
Left Atrium

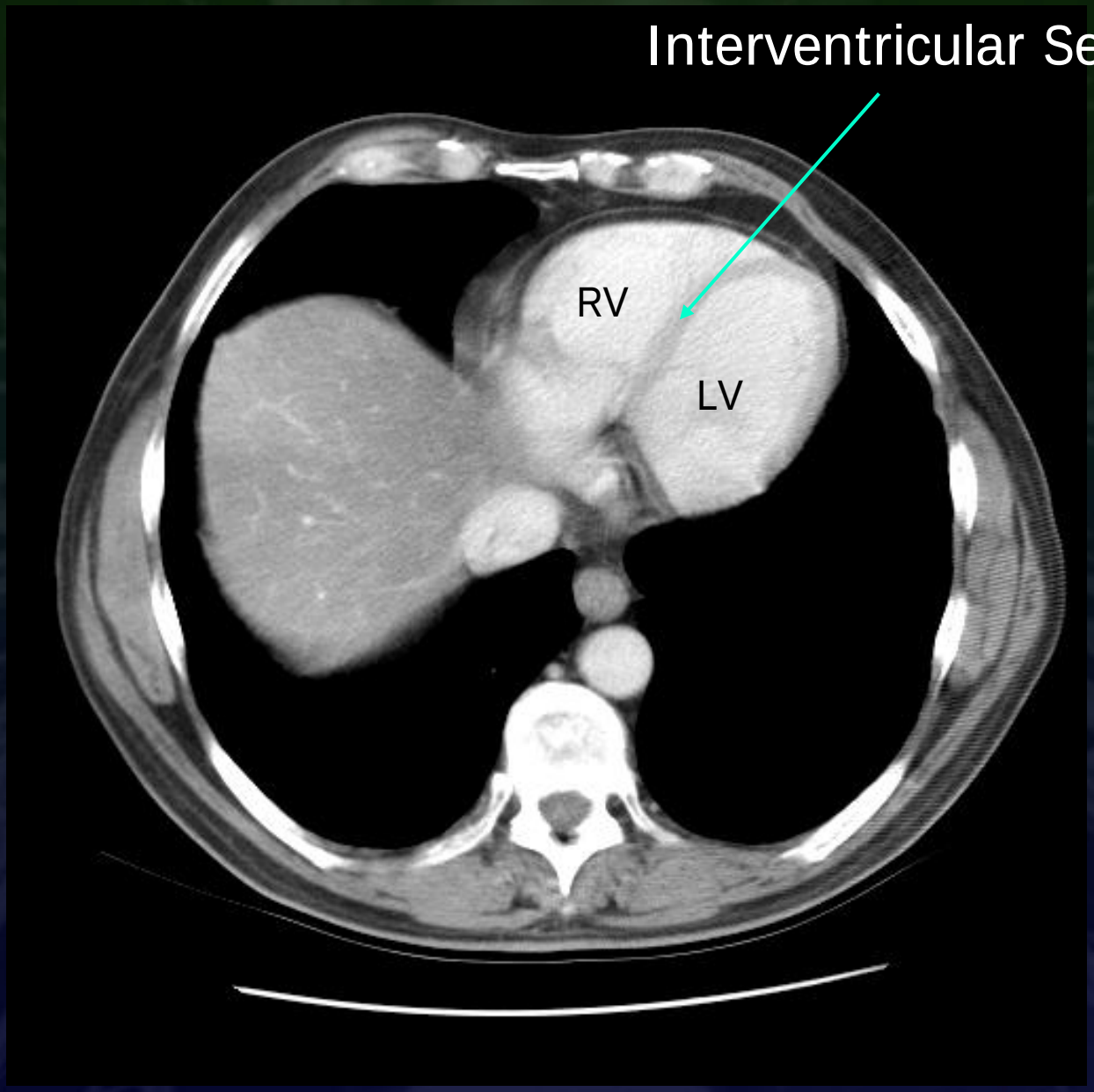

Azygos Vein
Oesophagus

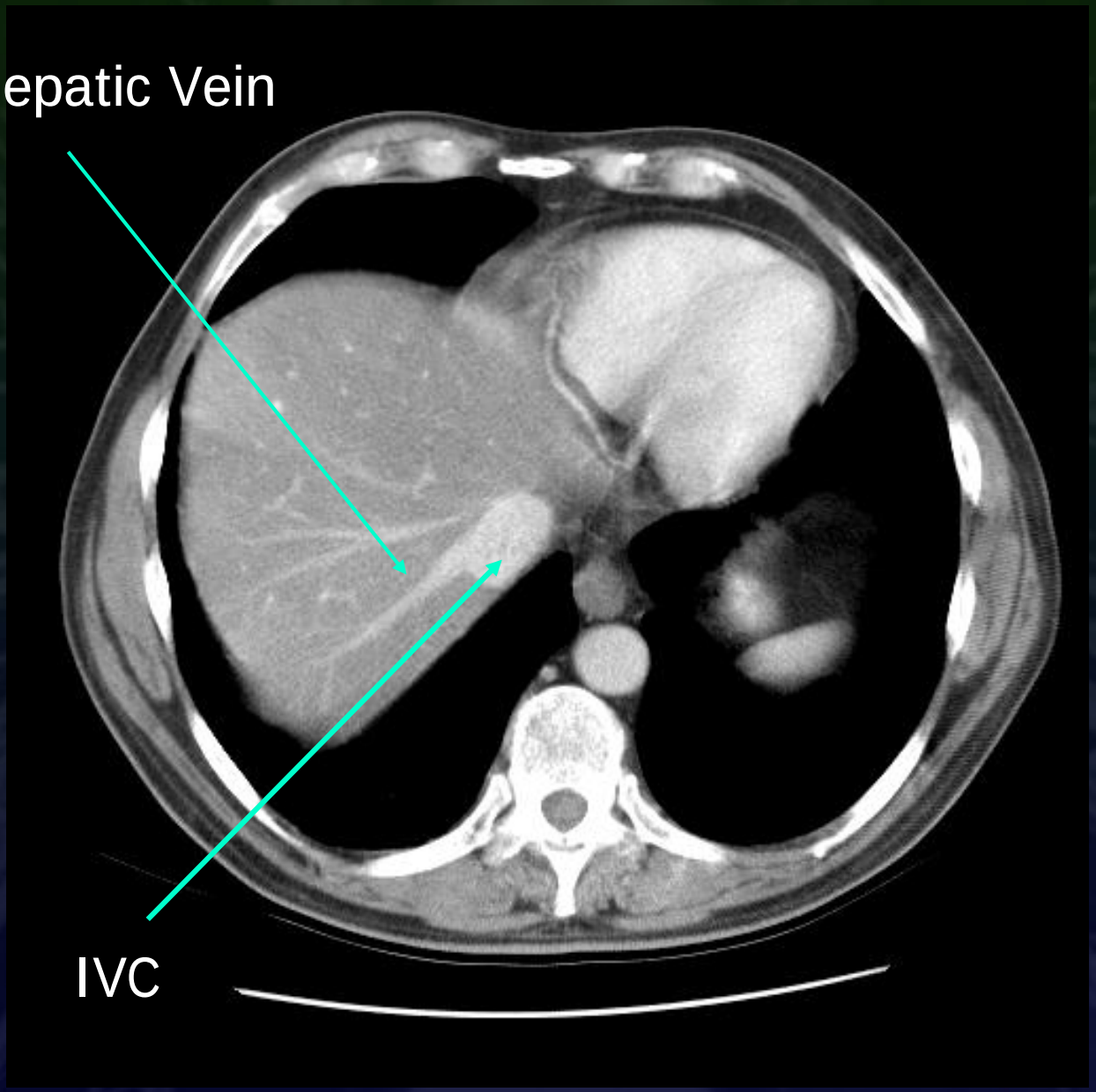

RA
LA

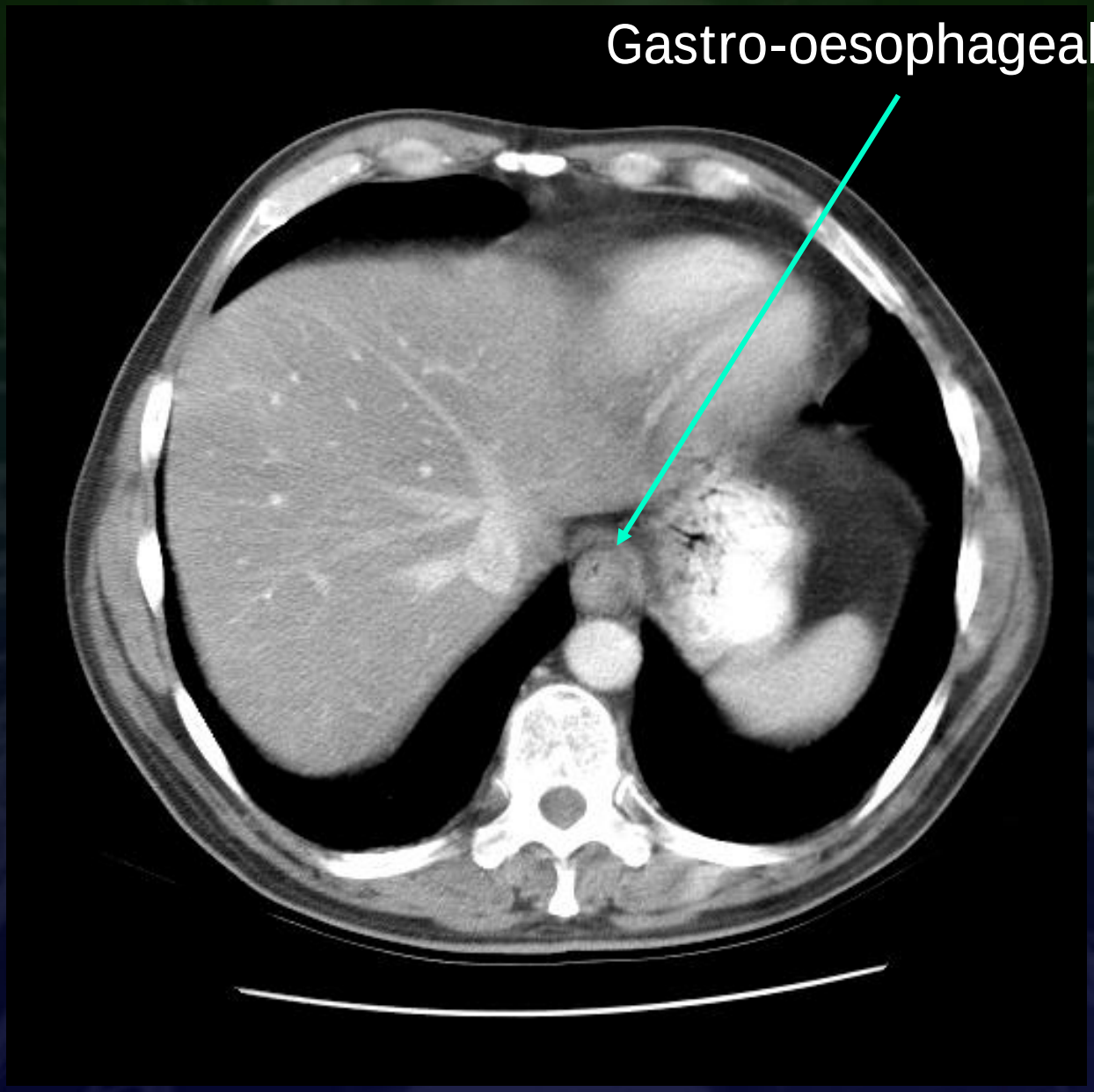




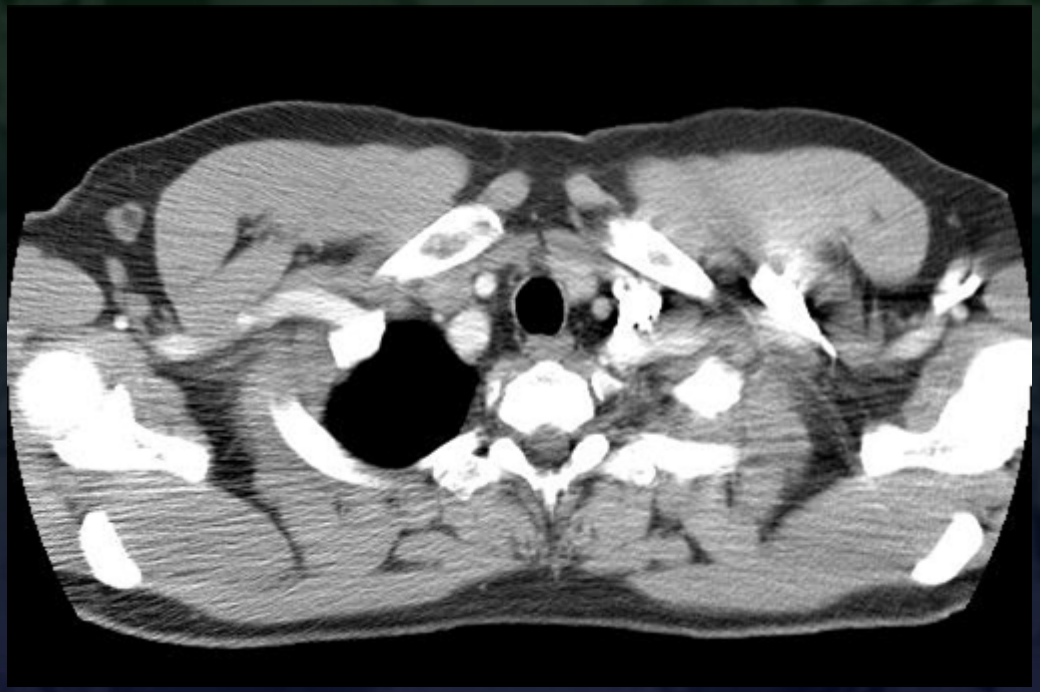

RV
LV
IVC

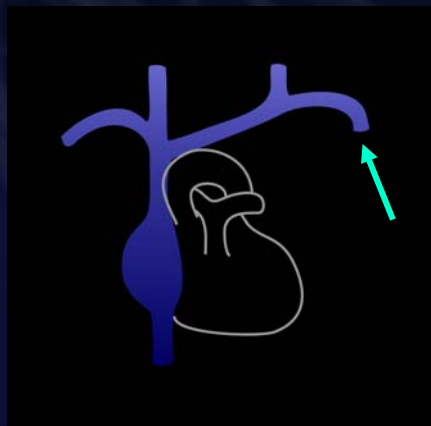

Interventricular Septum
RV
LV


Right Hepatic Vein
IVC

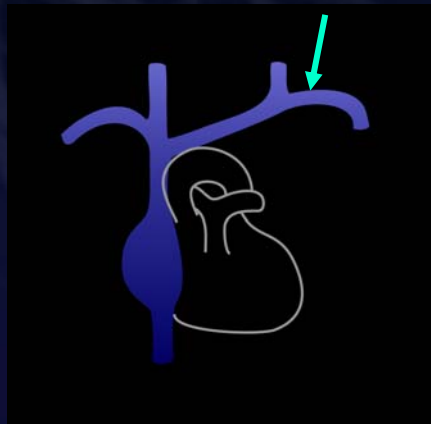

Gastro-oesophageal Junction

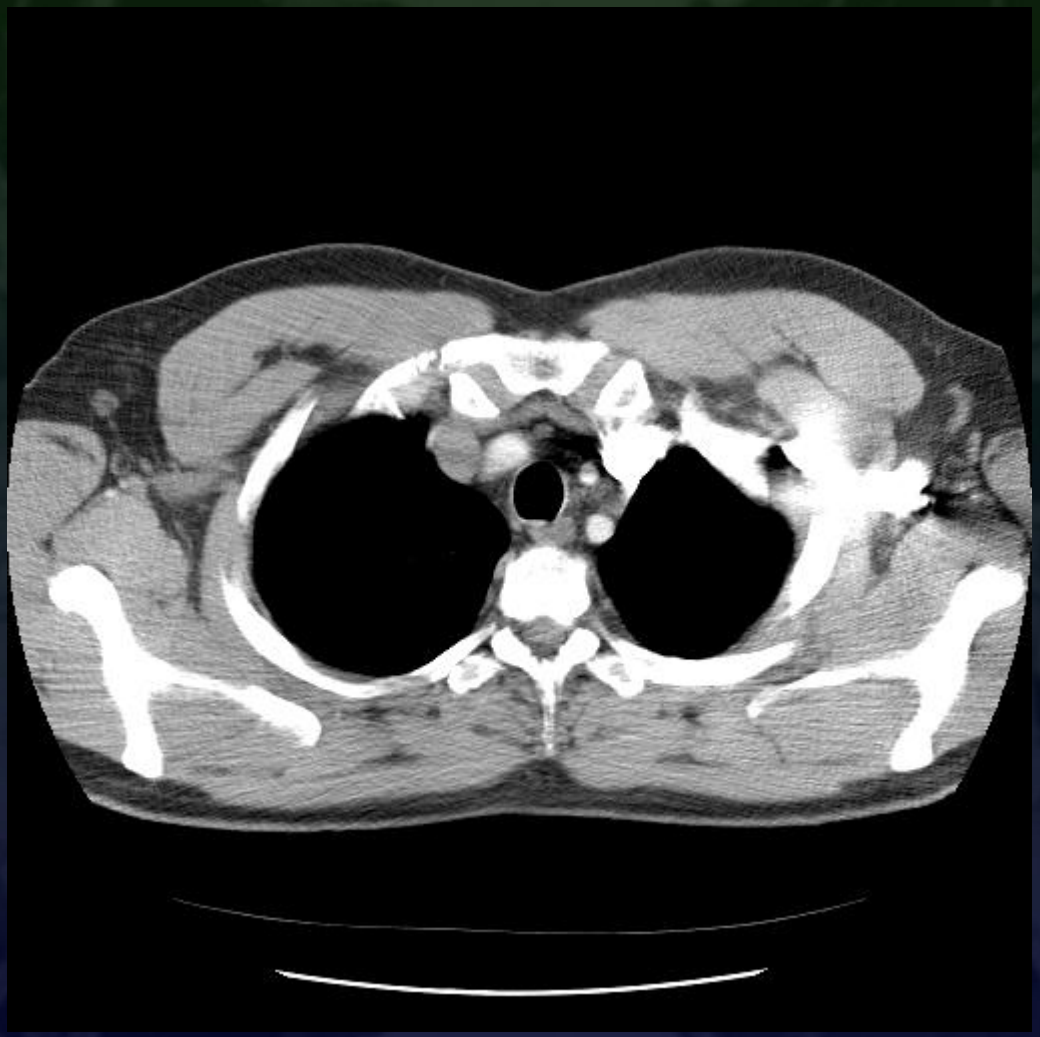
Venous Anatomy:
Left sided contrast injection

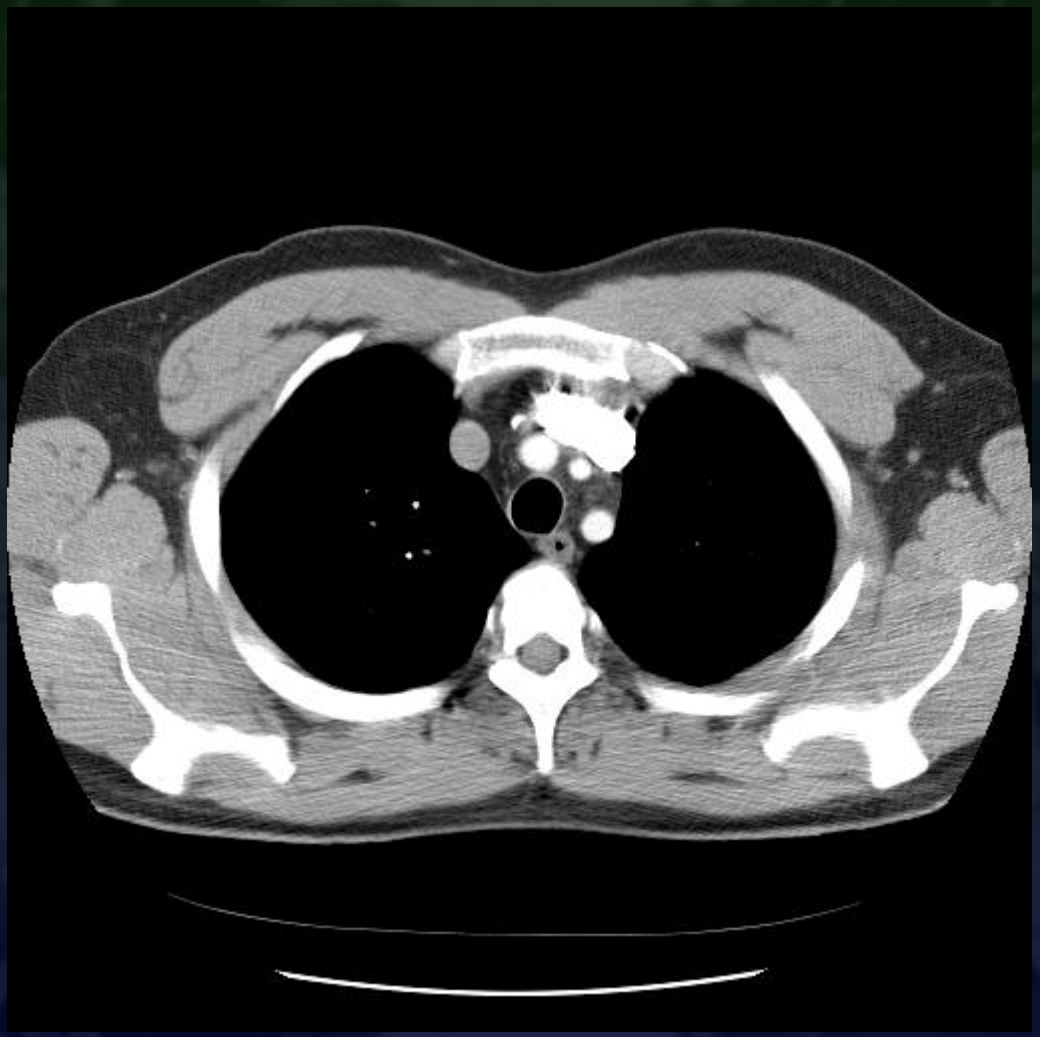




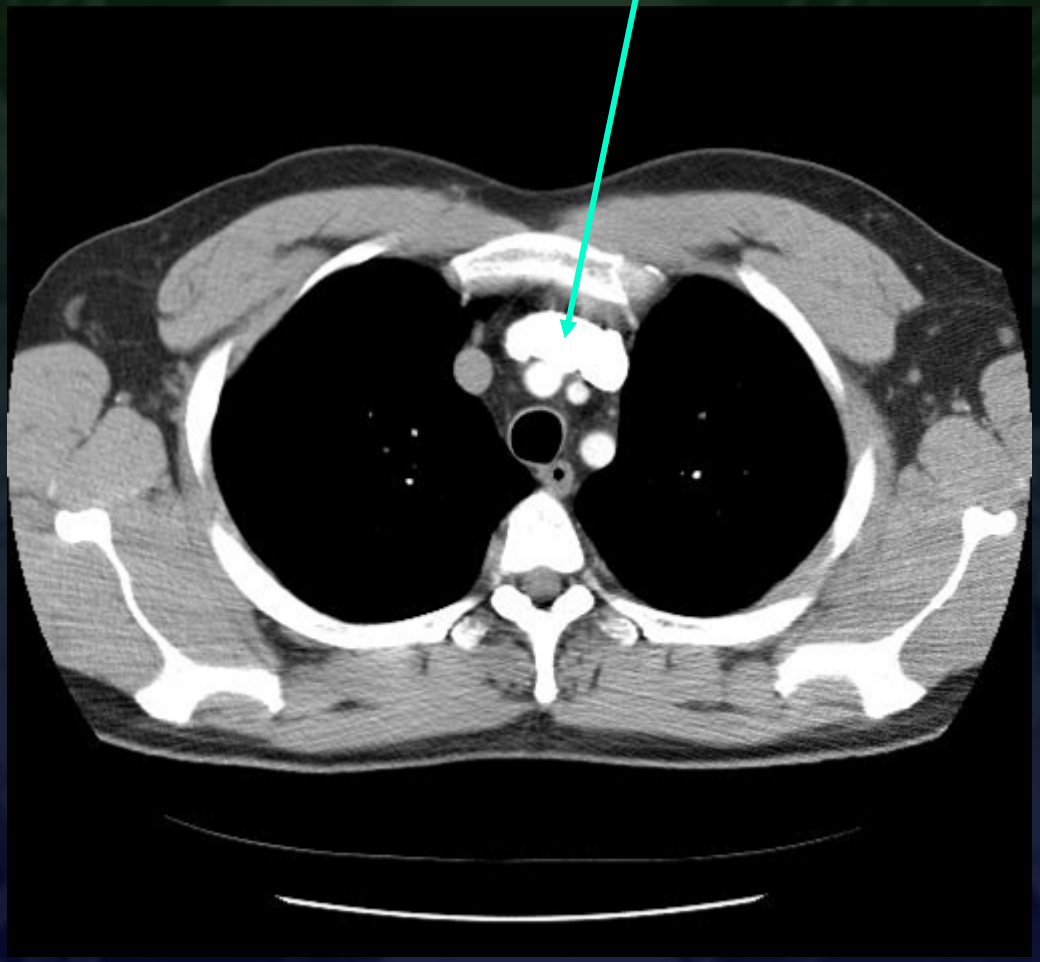
Contrast in left subclavian vein

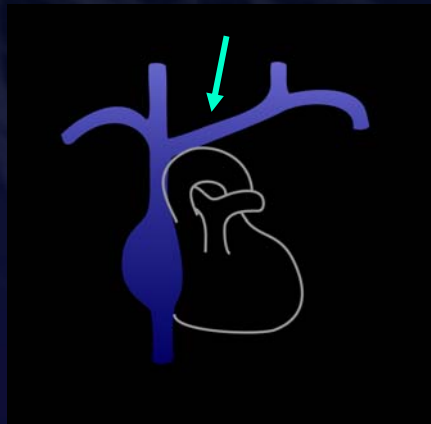


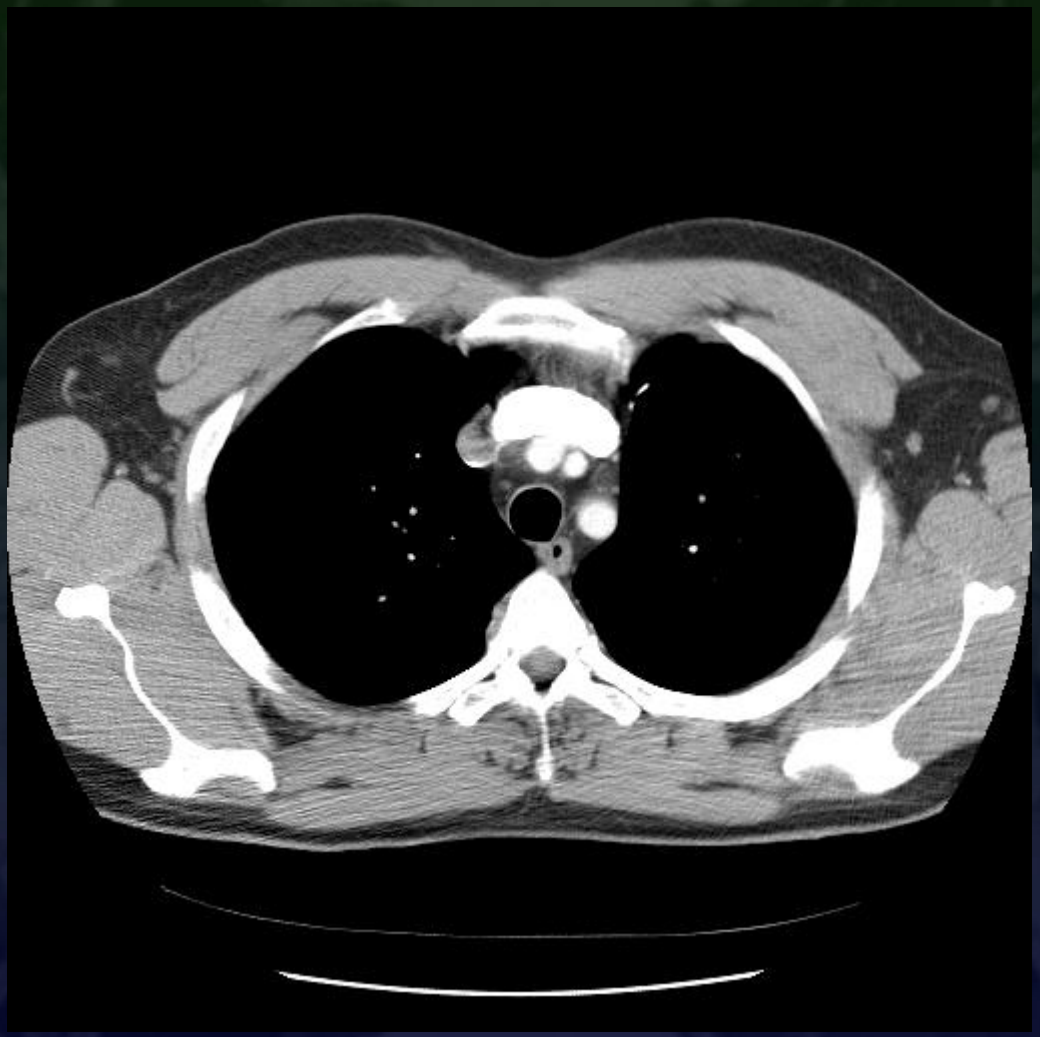


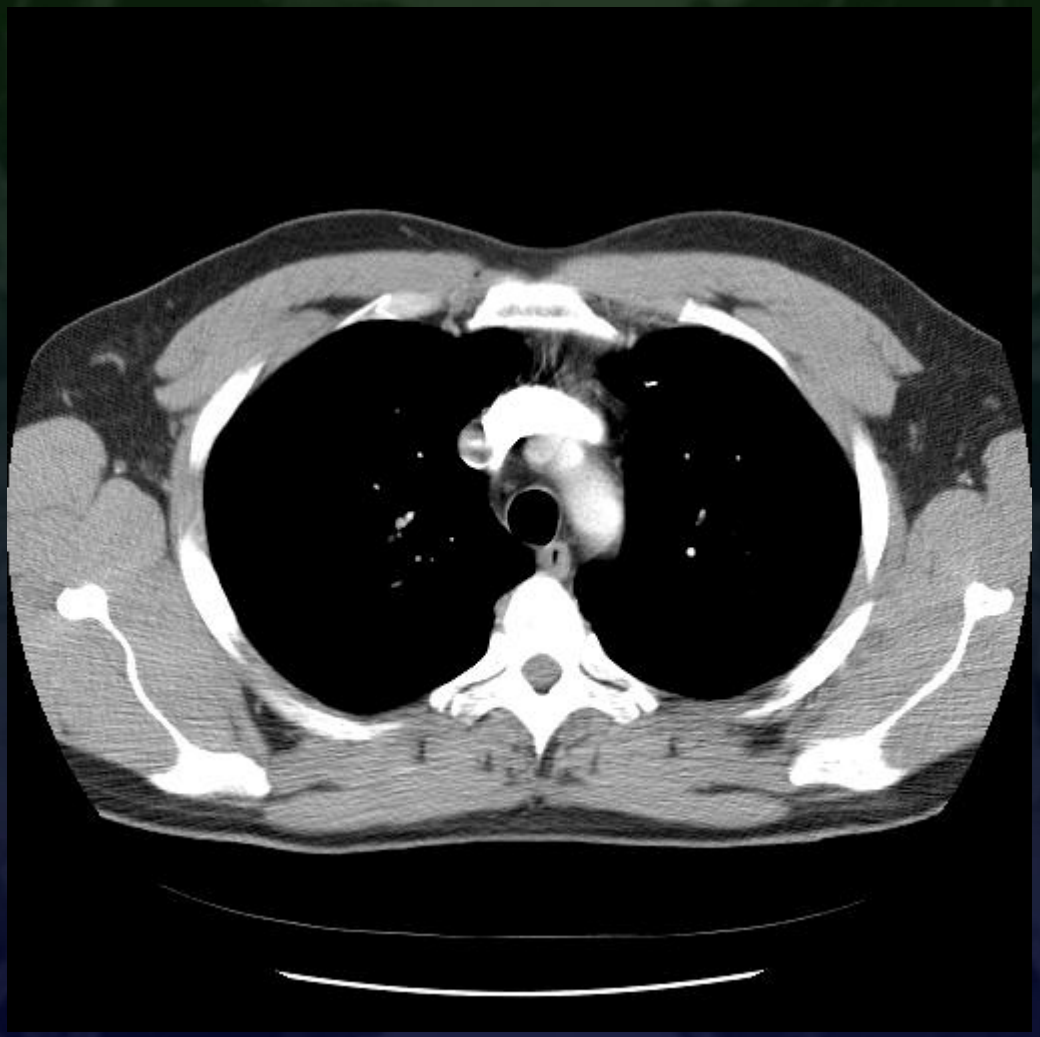


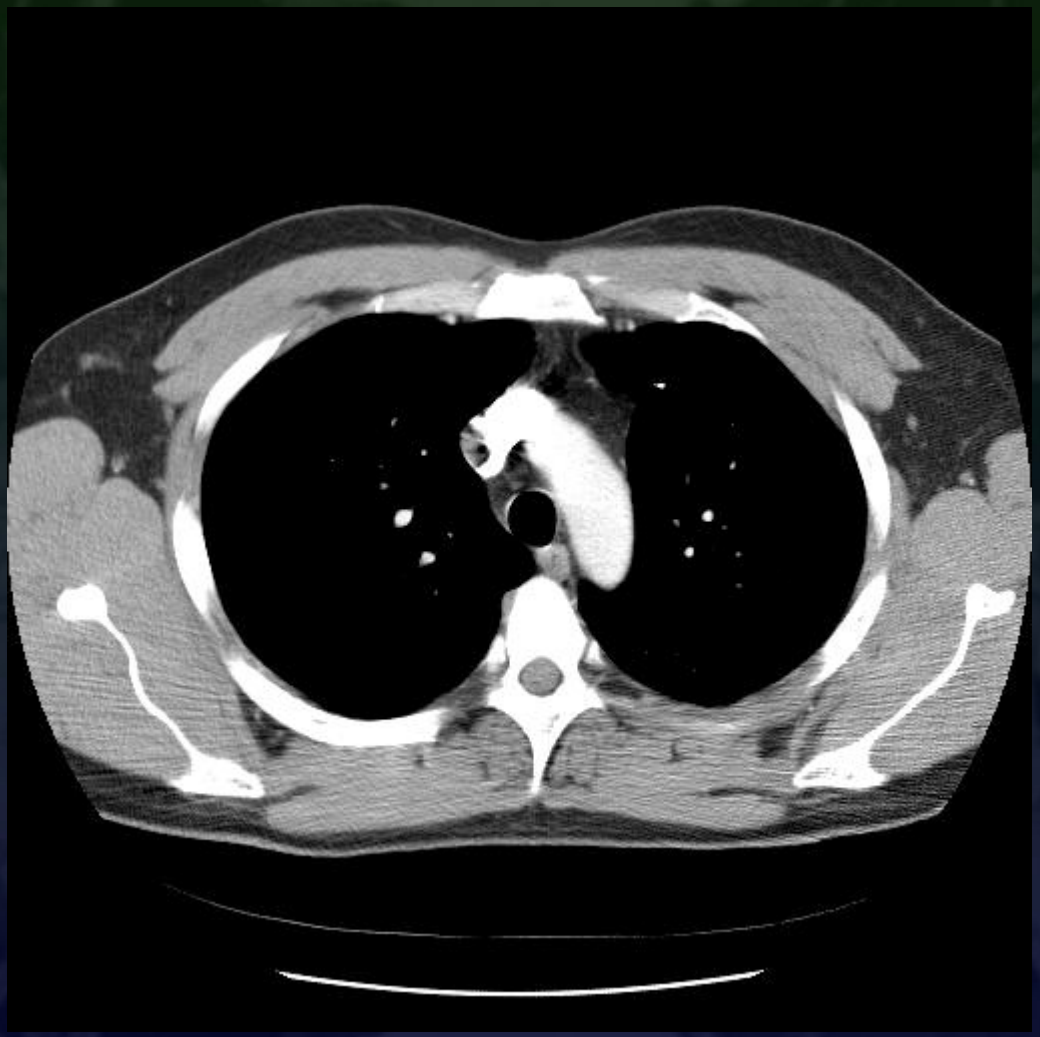
Left brachiocephalic vein
(enhancing with contrast)



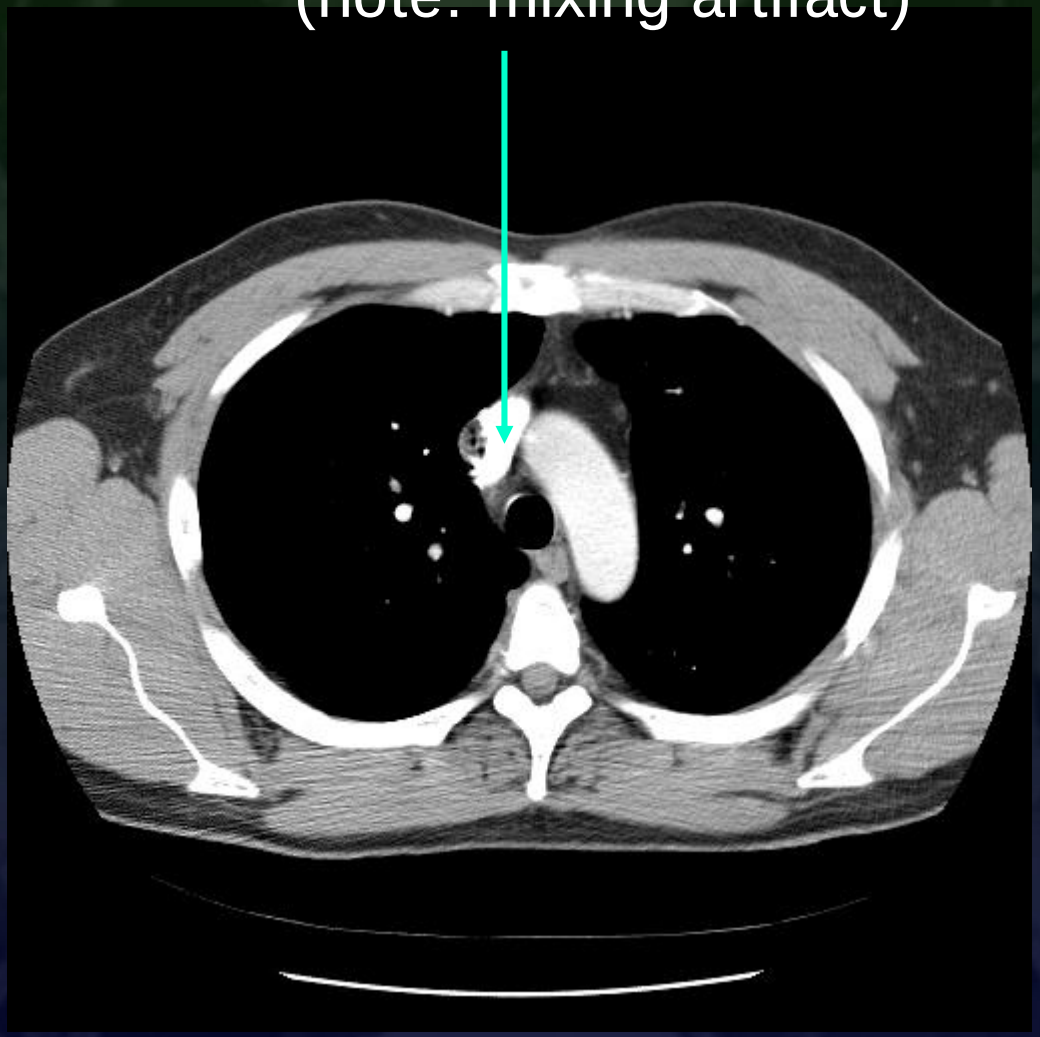


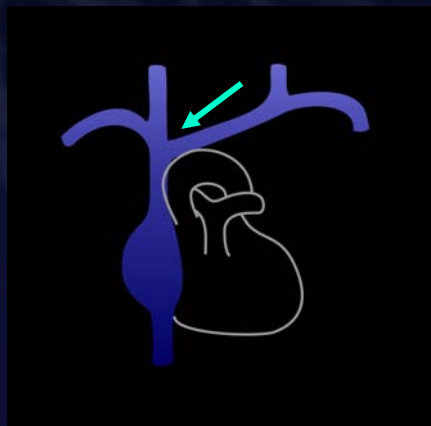




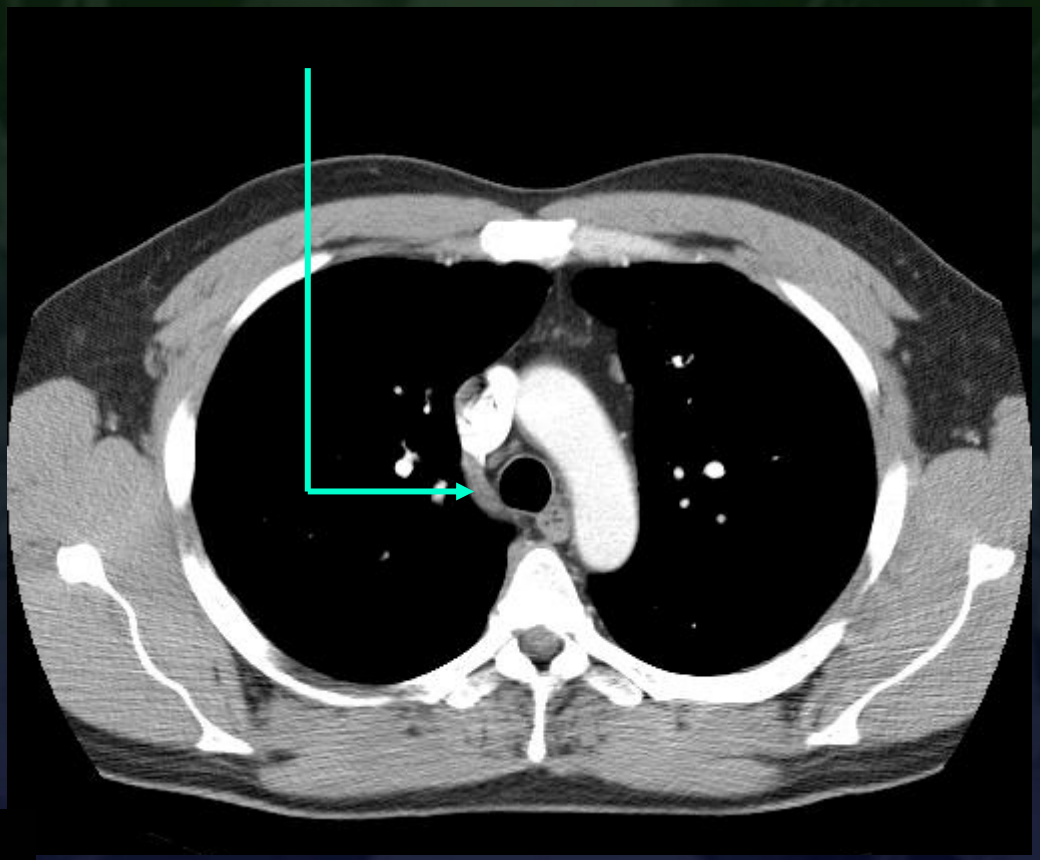


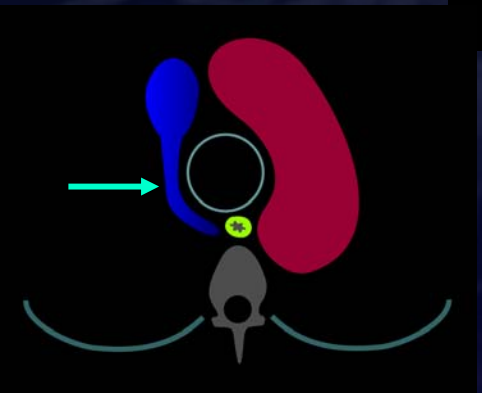
Contrast entering SVC
(note: mixing artifact)





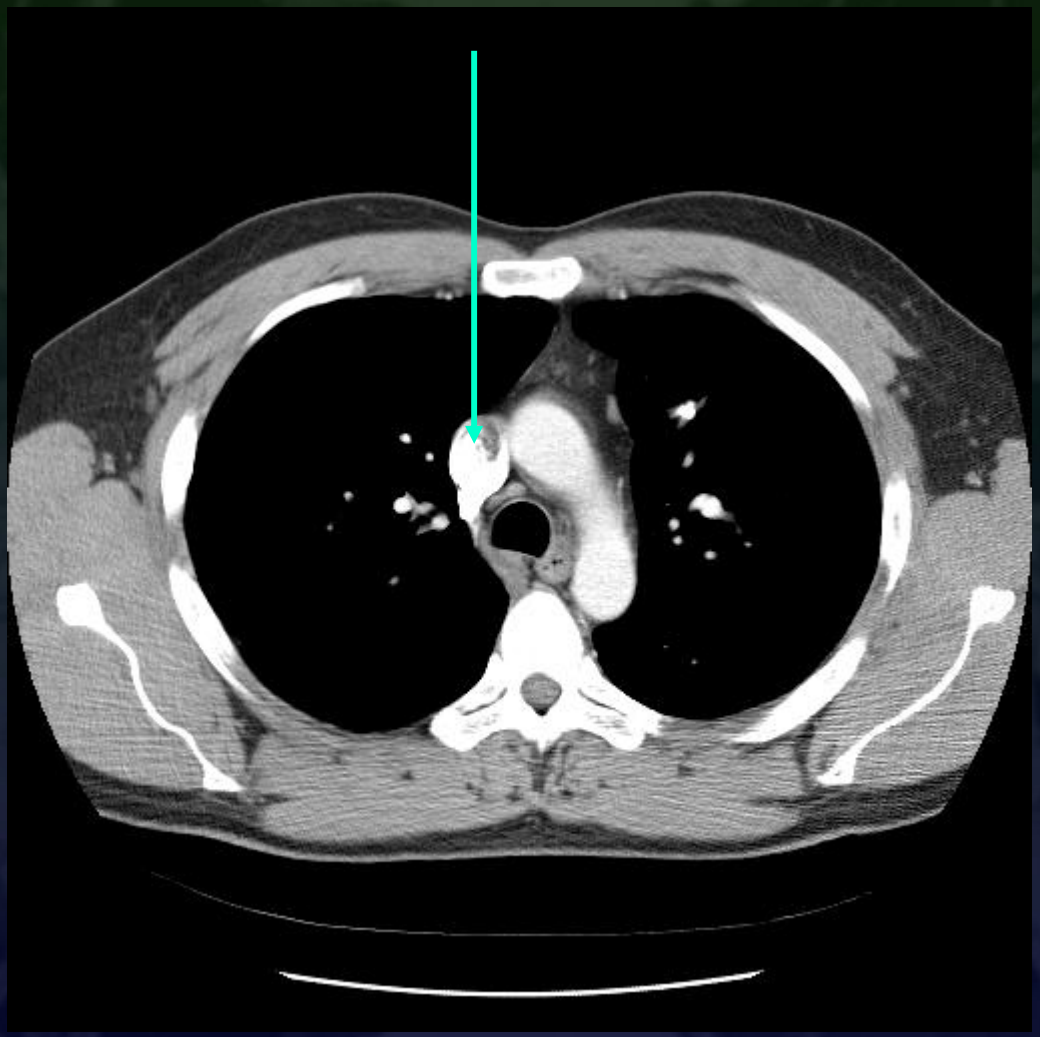
Azygos vein
(unopacified – no contrast reflux)

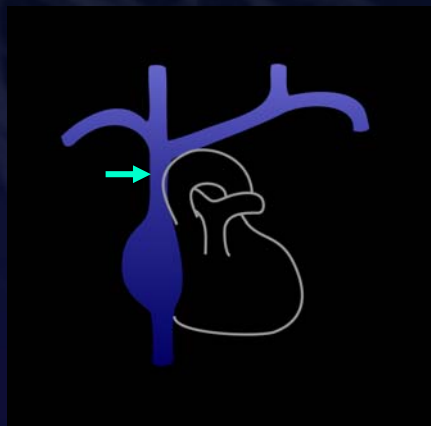


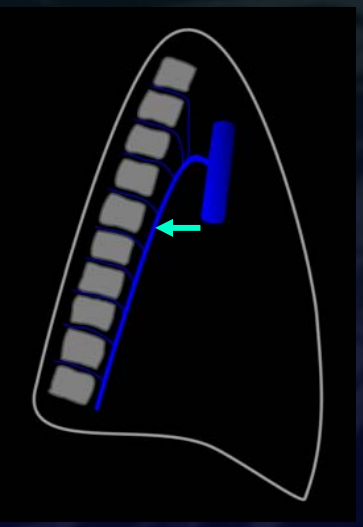


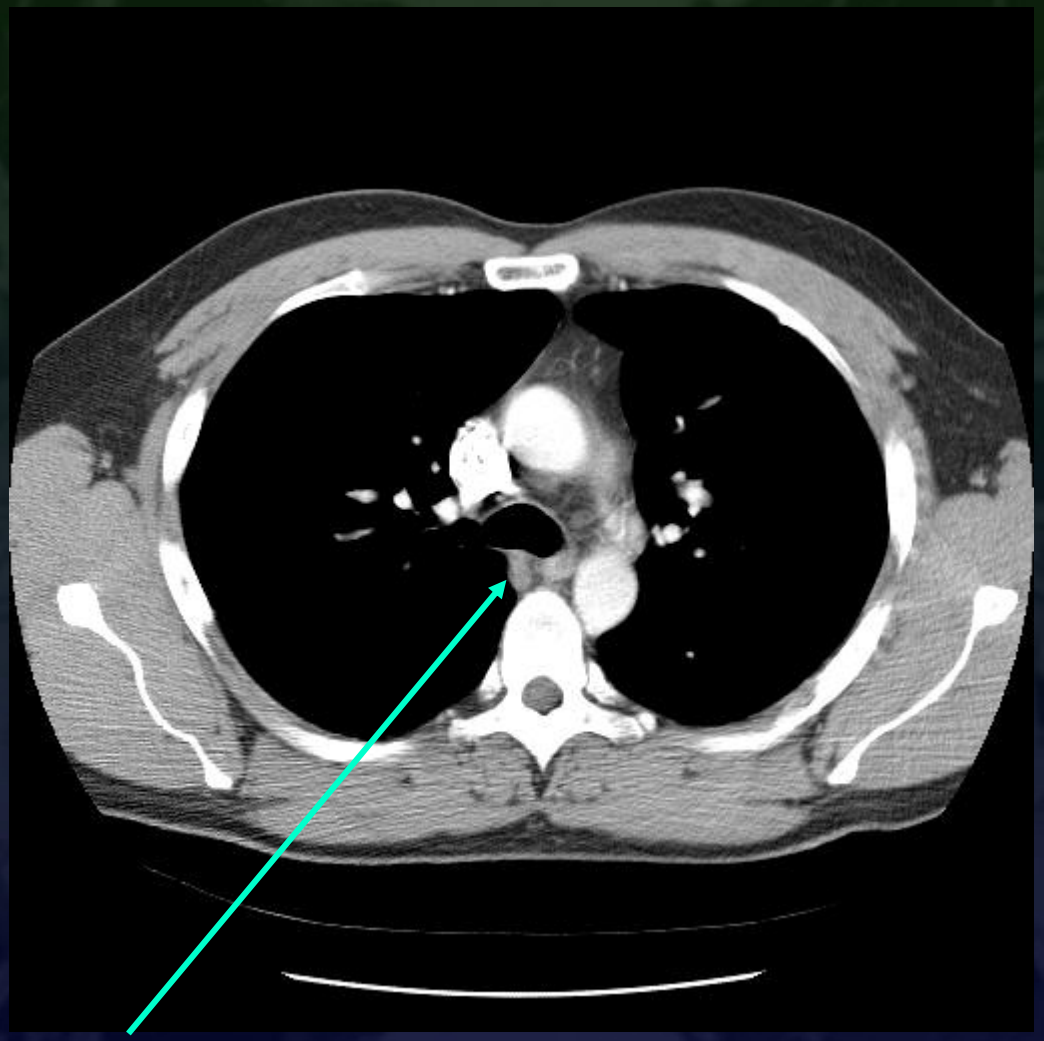
Beware! Do not mistake this normal structure for "right paratracheal lymphadenopathy"….

SVC

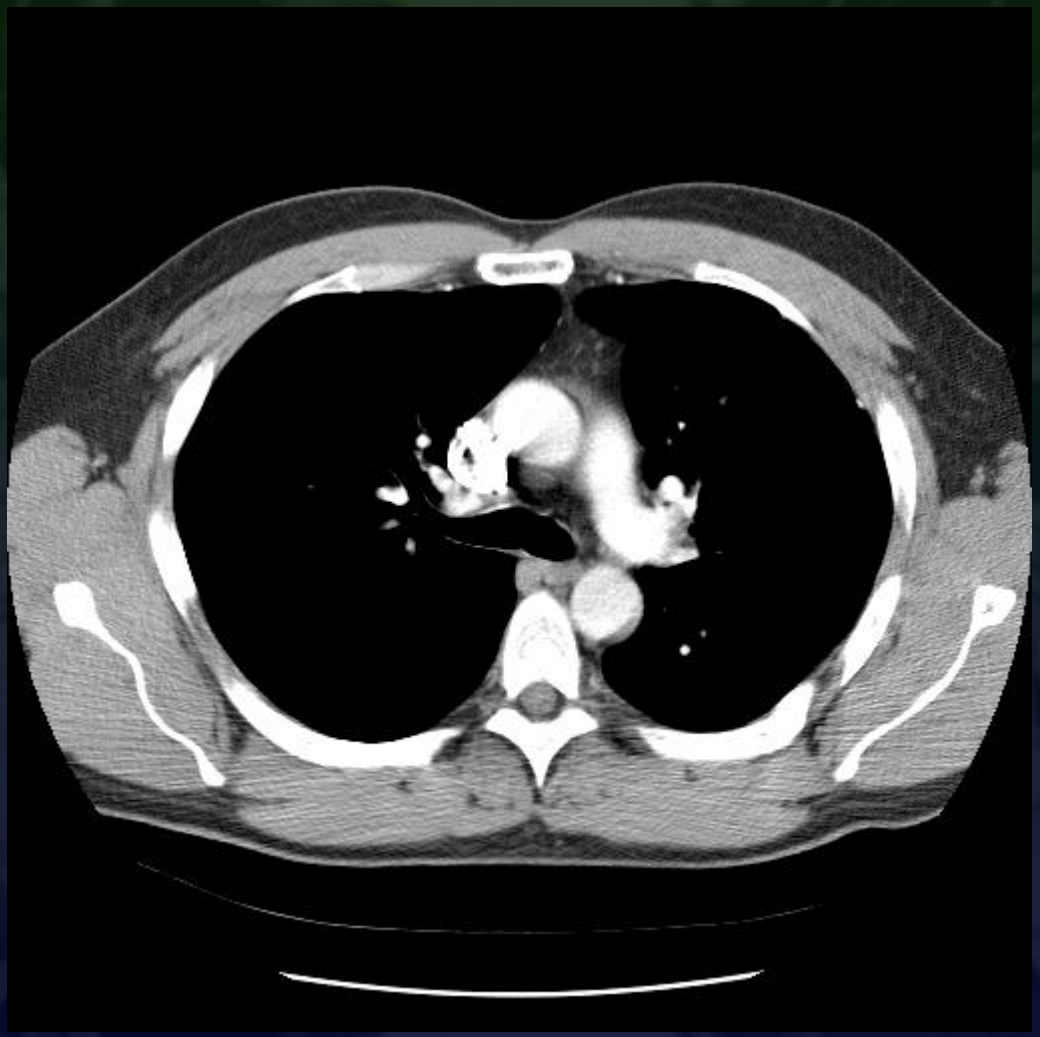


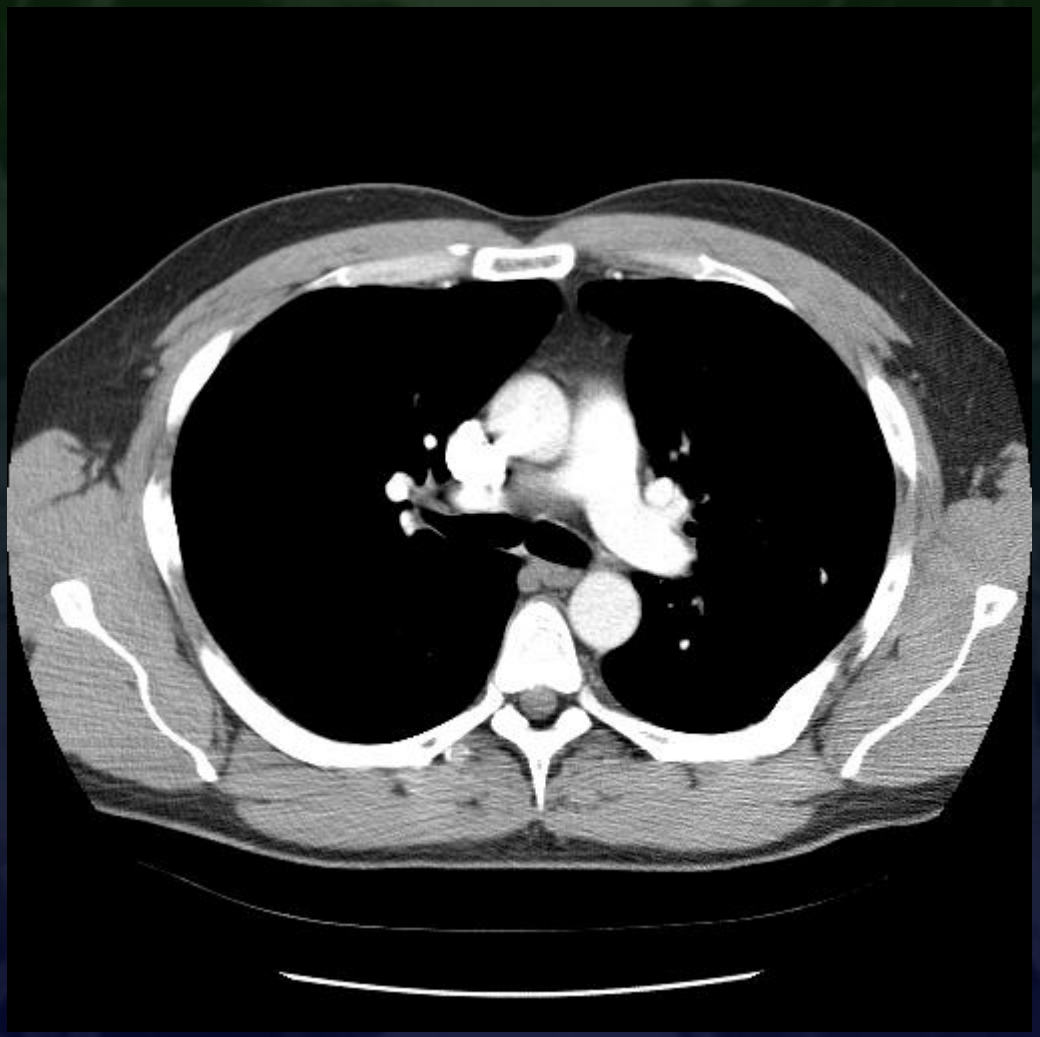




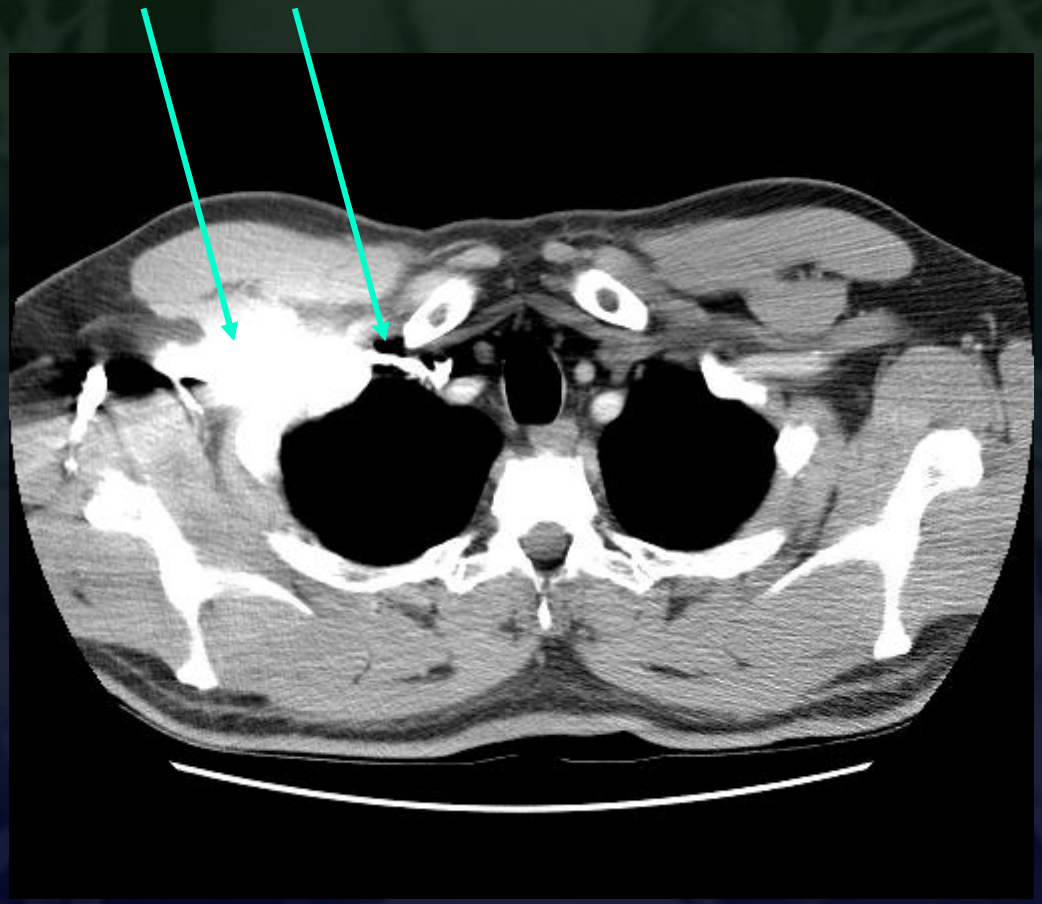


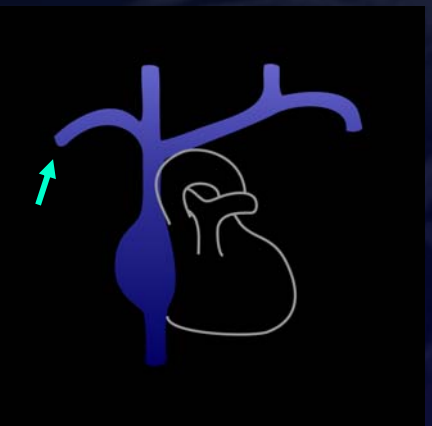
Azygos vein (vertical segment) in posterior mediastinum



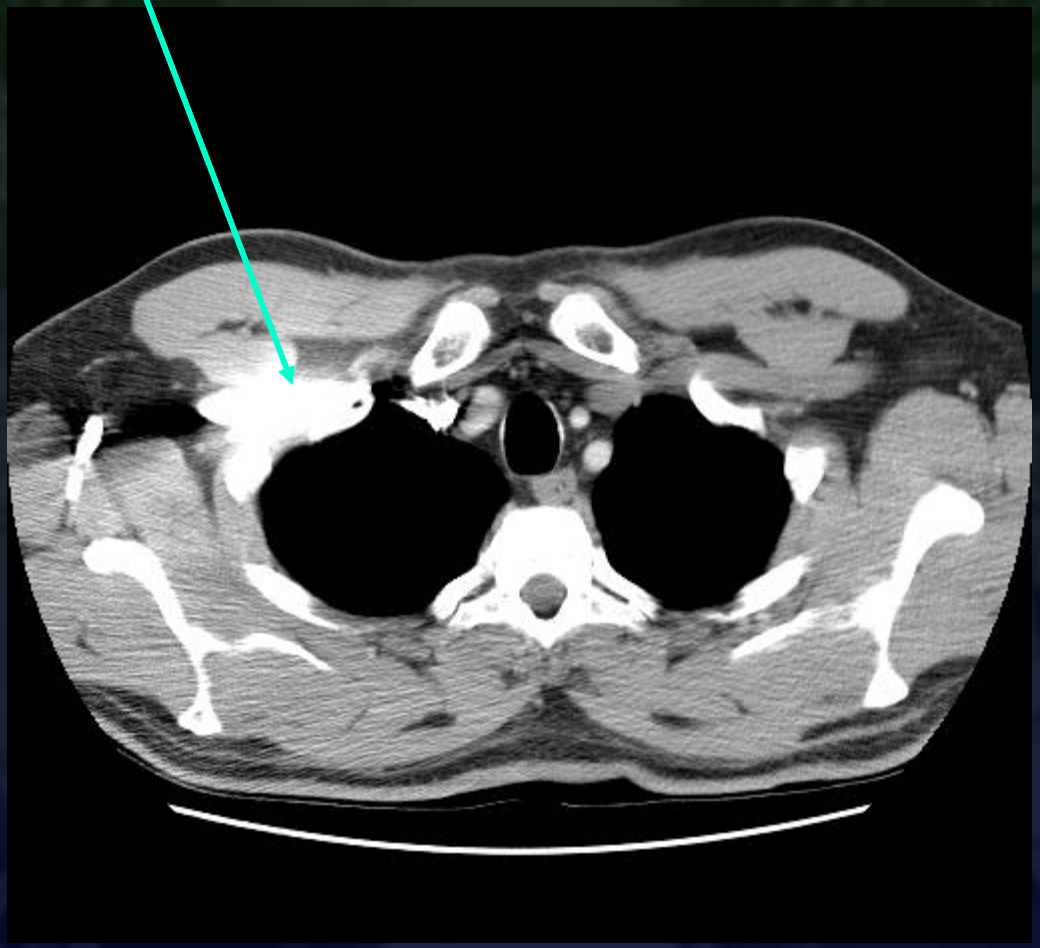


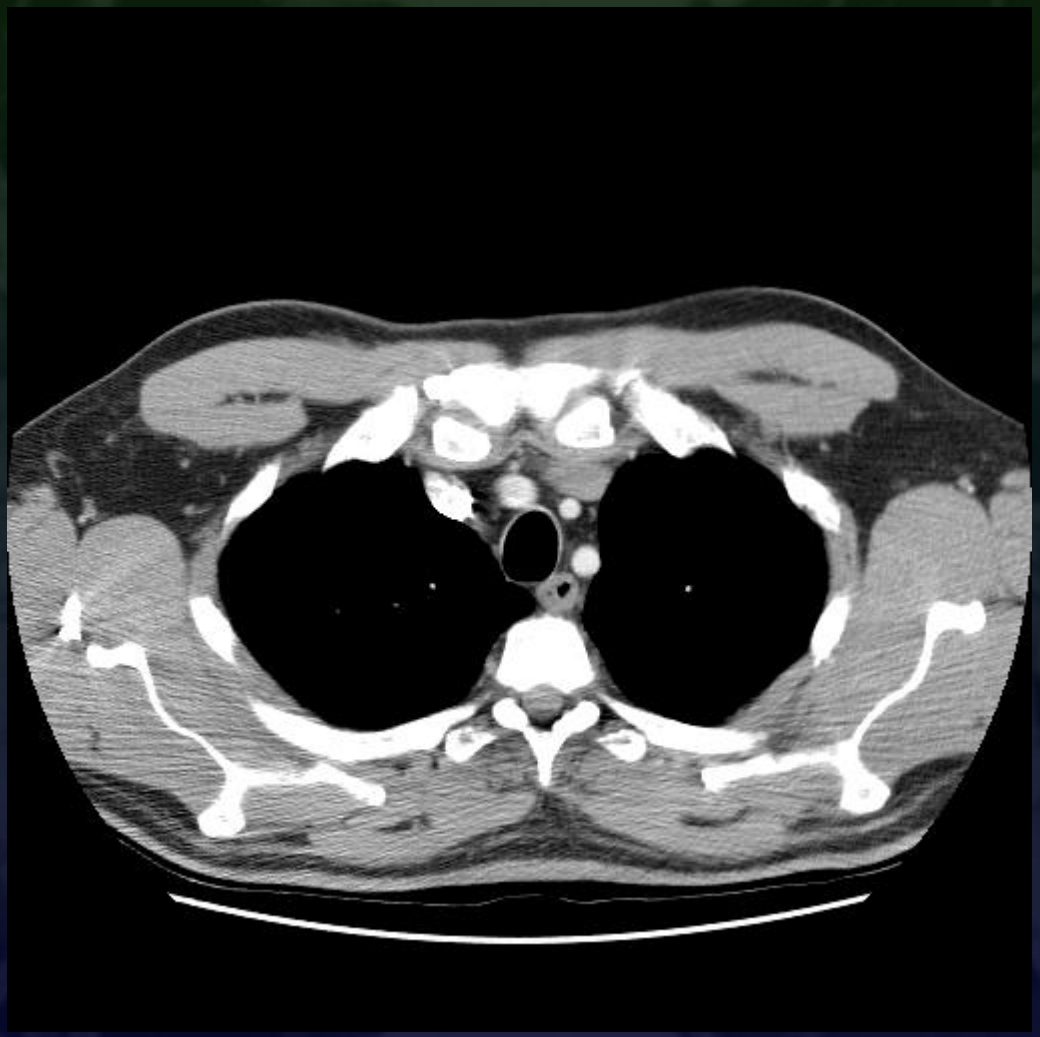
Venous Anatomy:
Right sided contrast injection

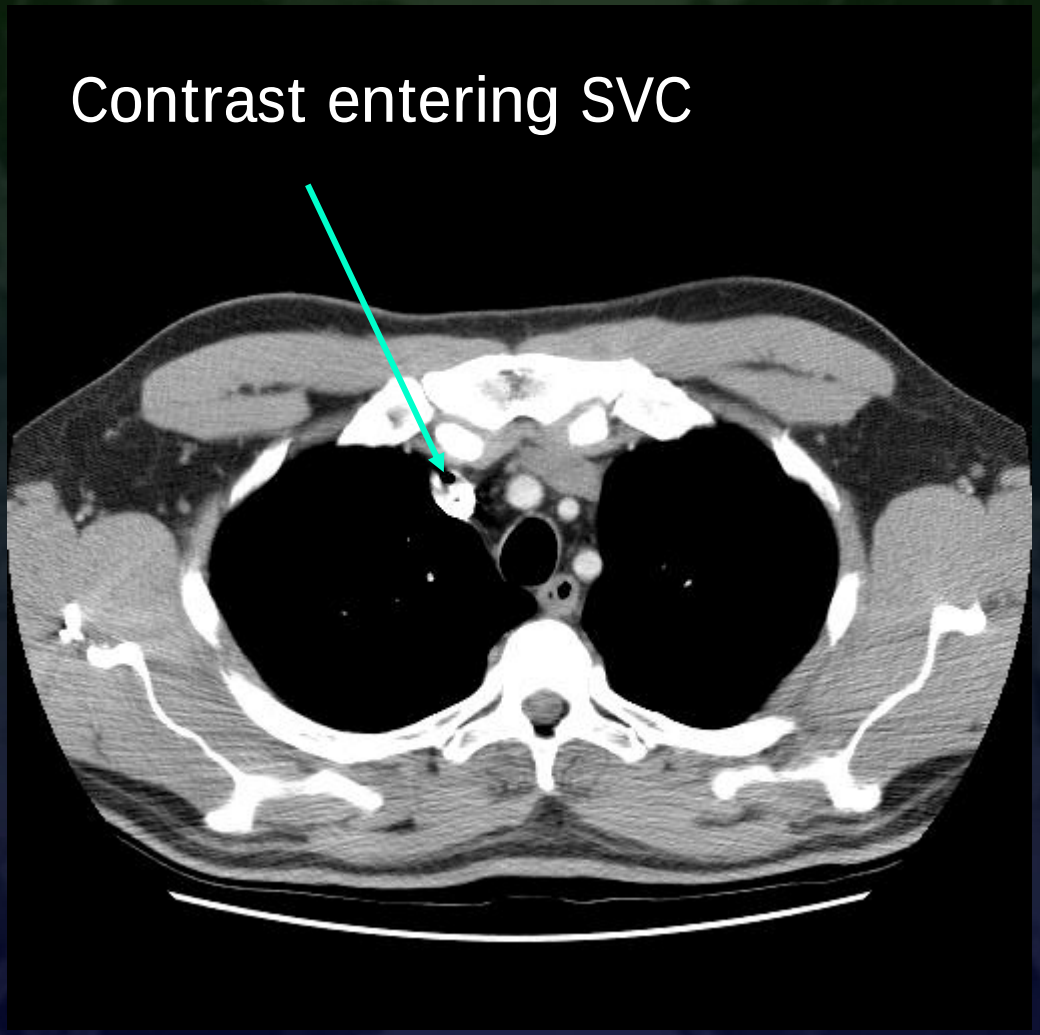




Contrast in right subclavian vein

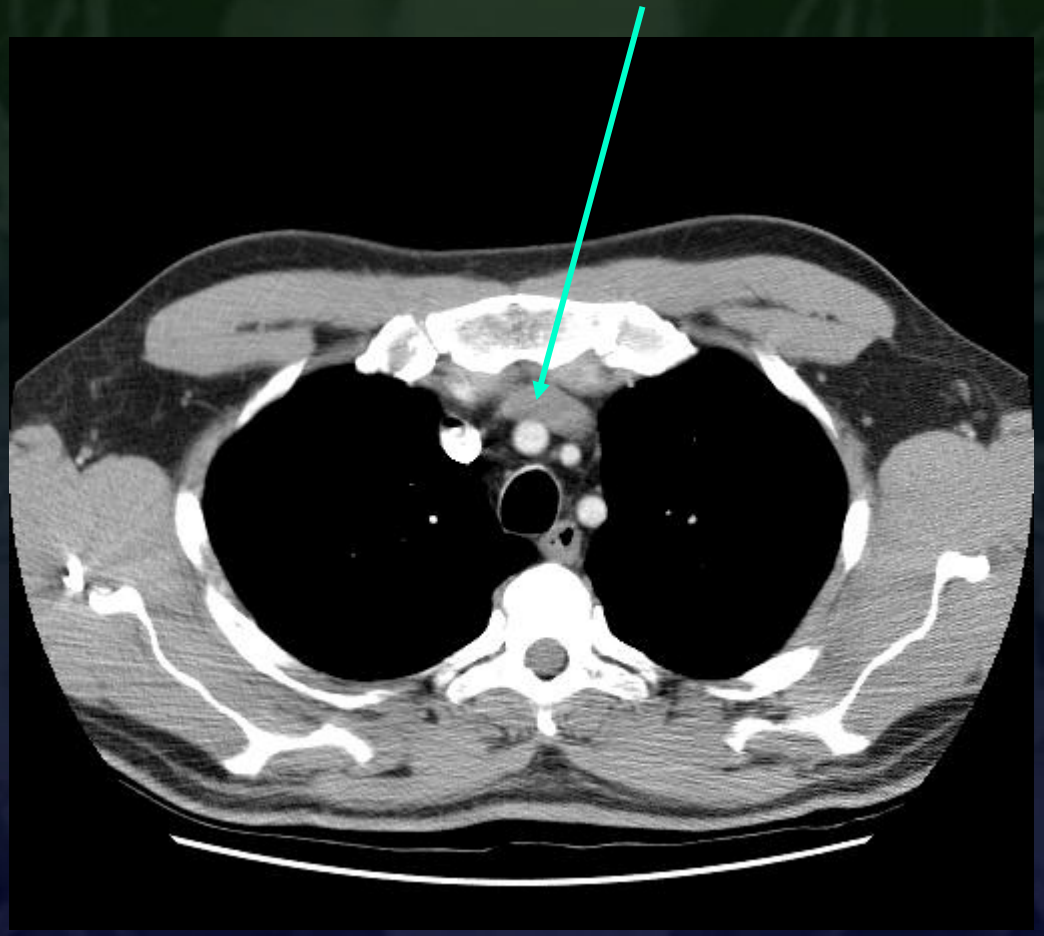




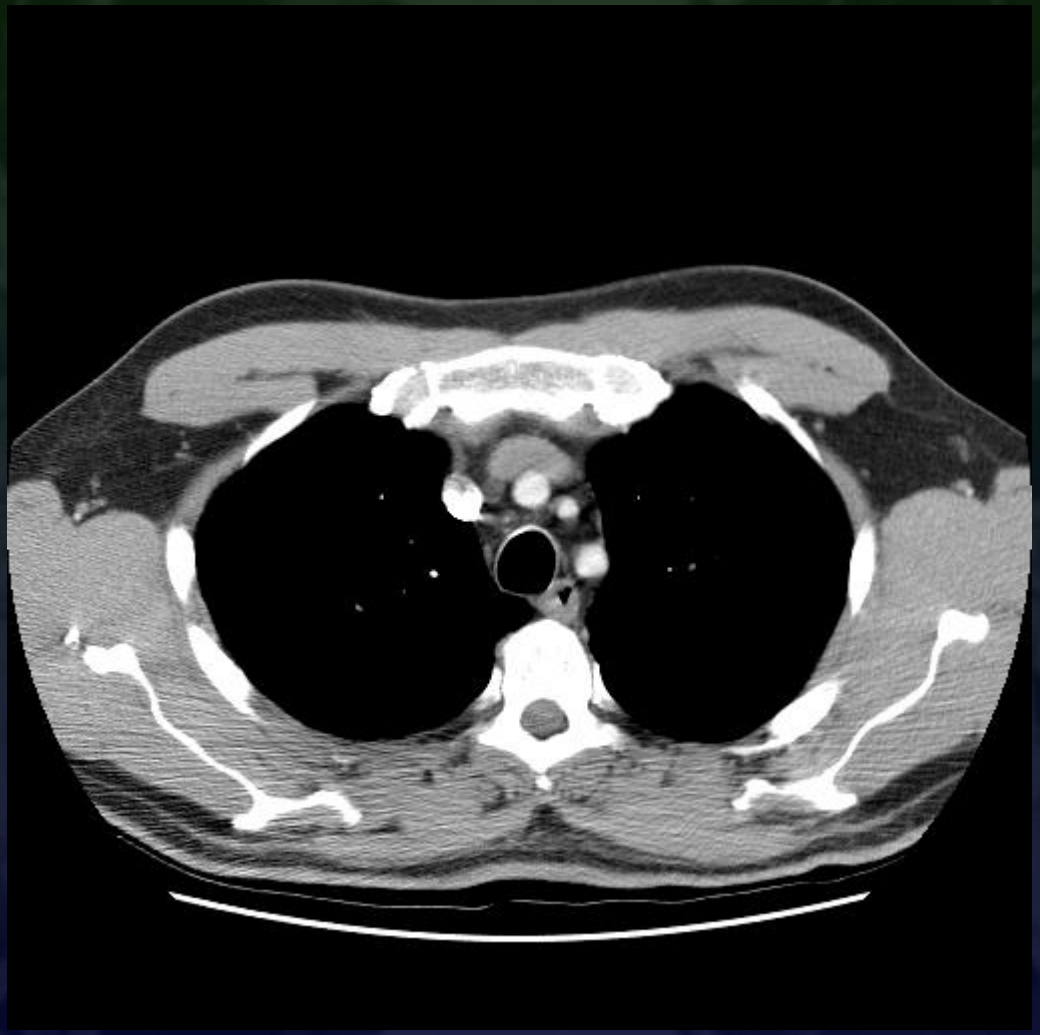

Contrast entering SVC

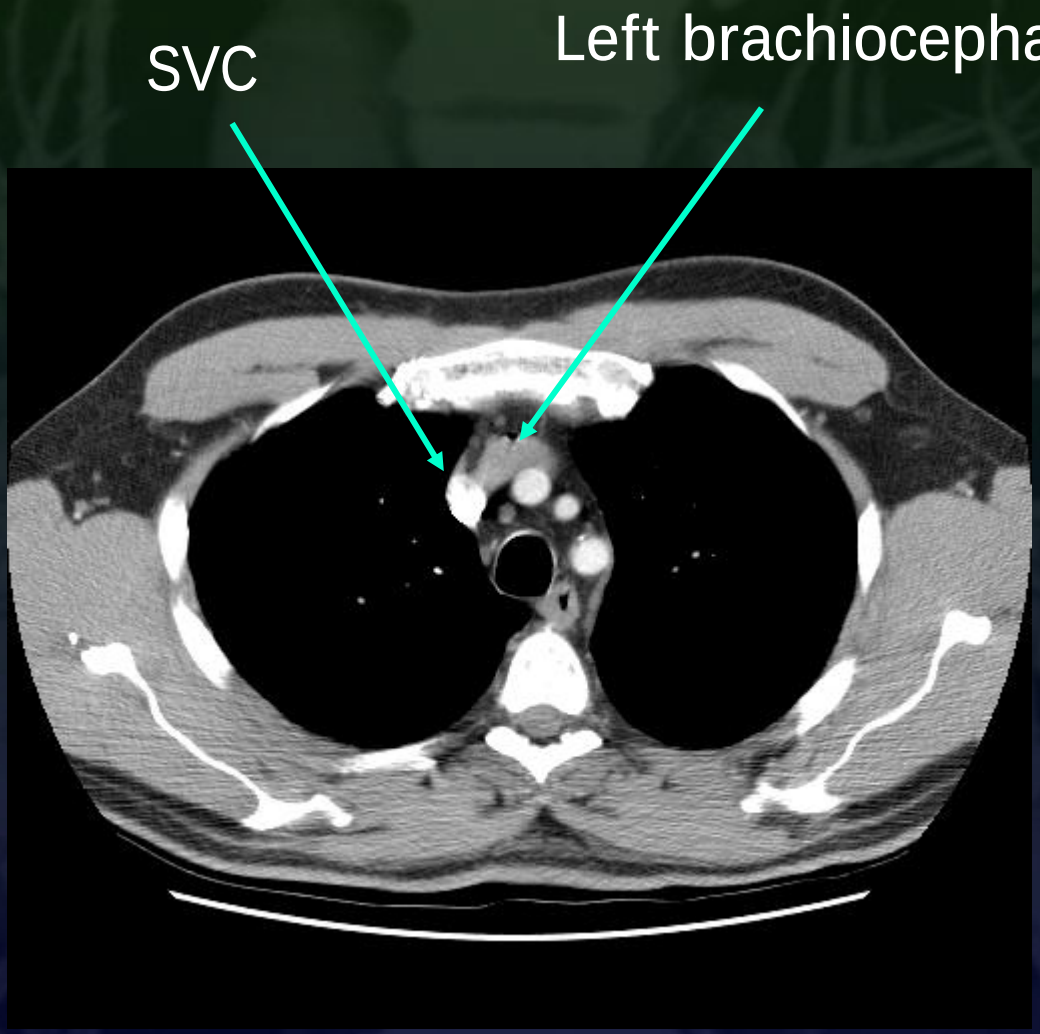
Left brachiocephalic vein

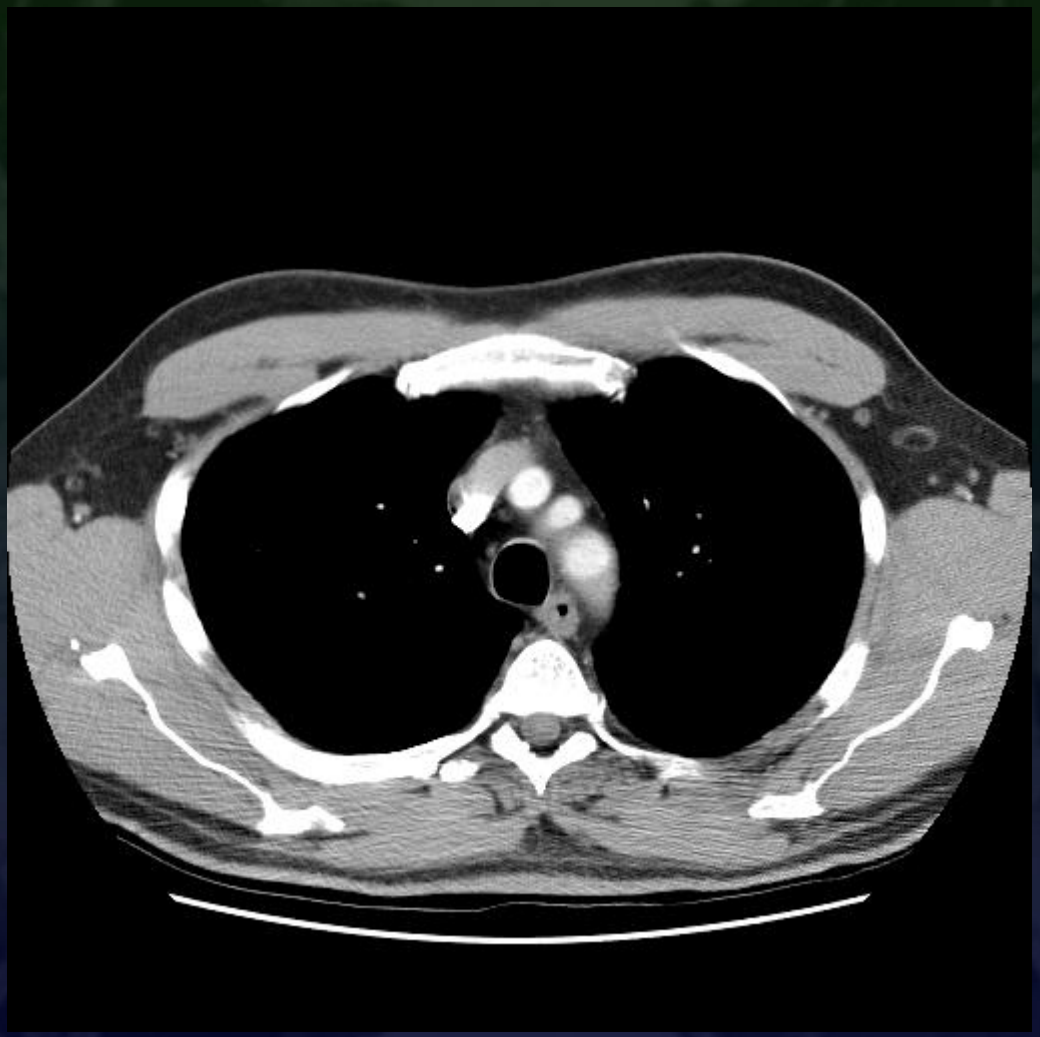
(unless there is reflux of contrast, no enhancement is seen)

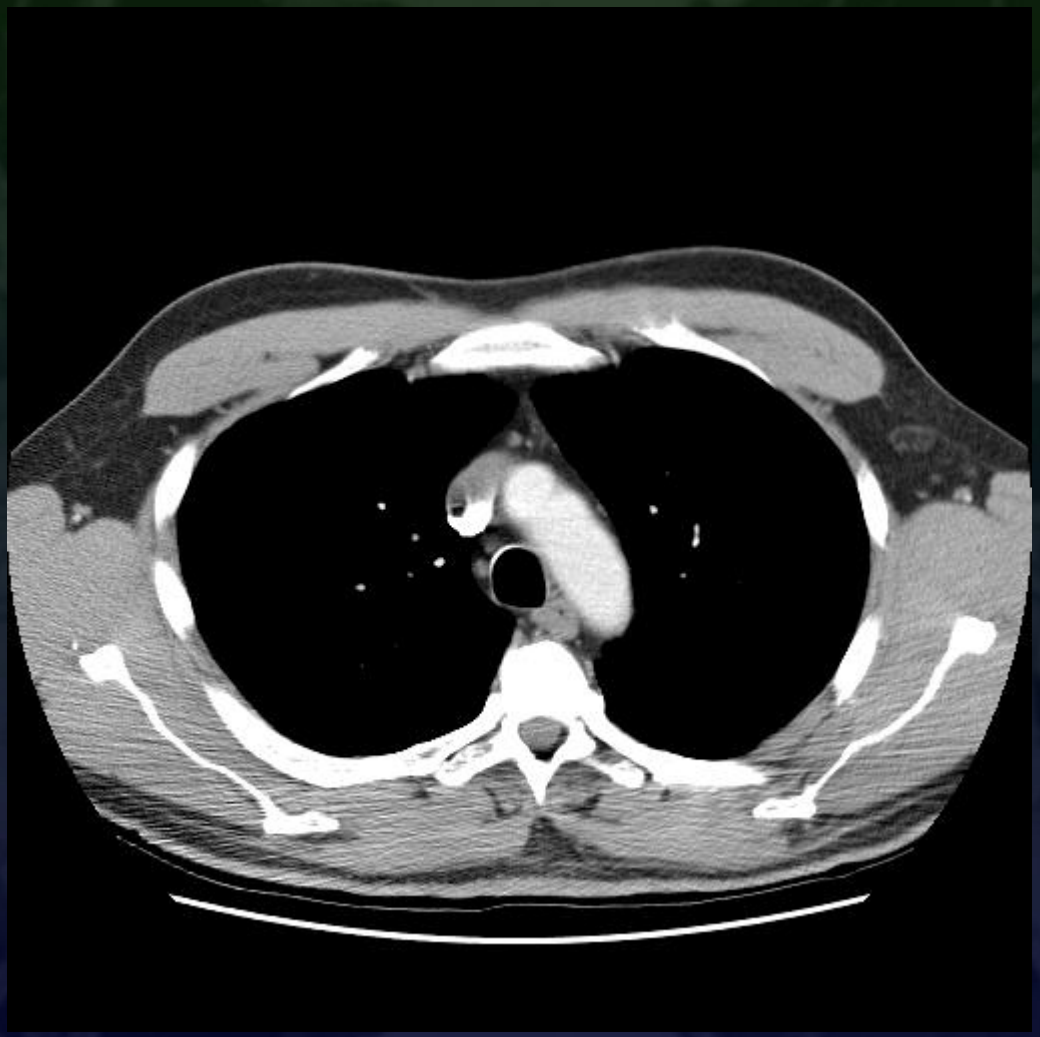


Beware! Do not mistake this normal structure for "anterior mediastinal lymphadenopathy"....

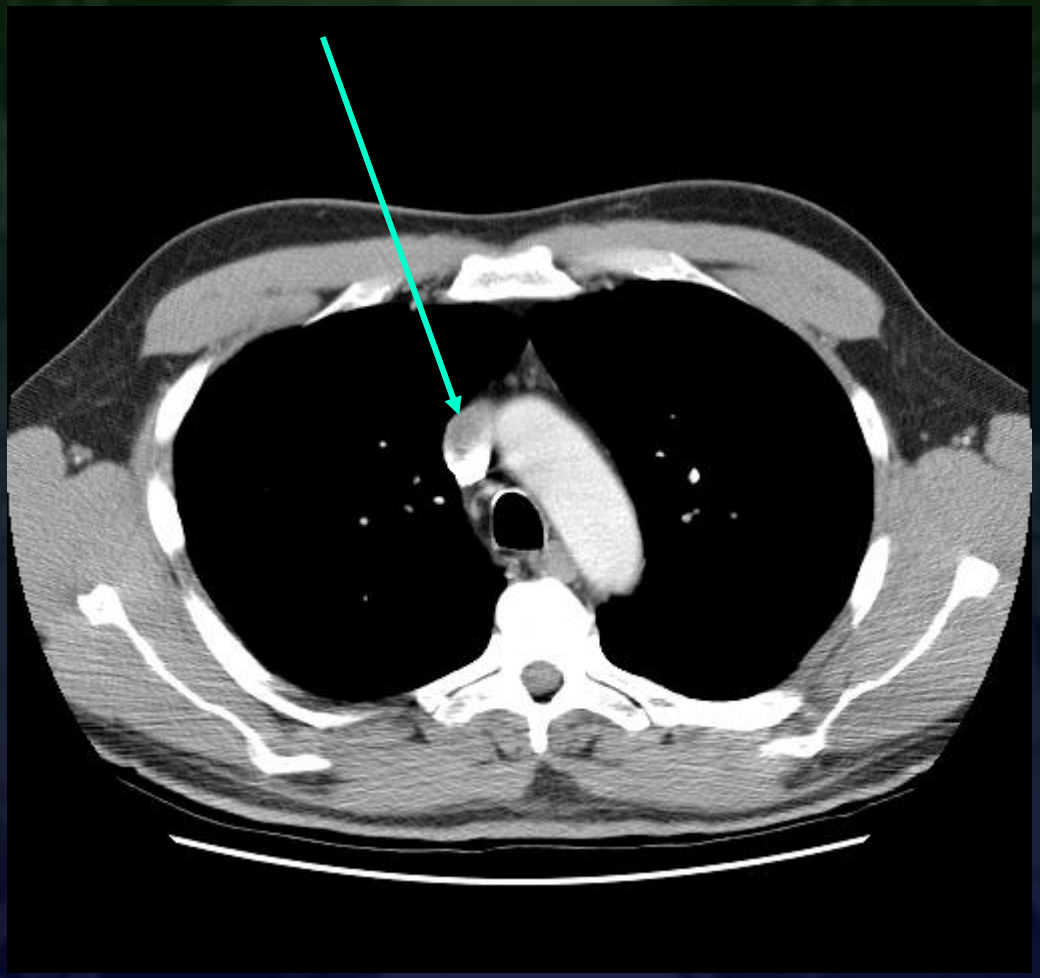



SVC
Left brachiocephalic vein



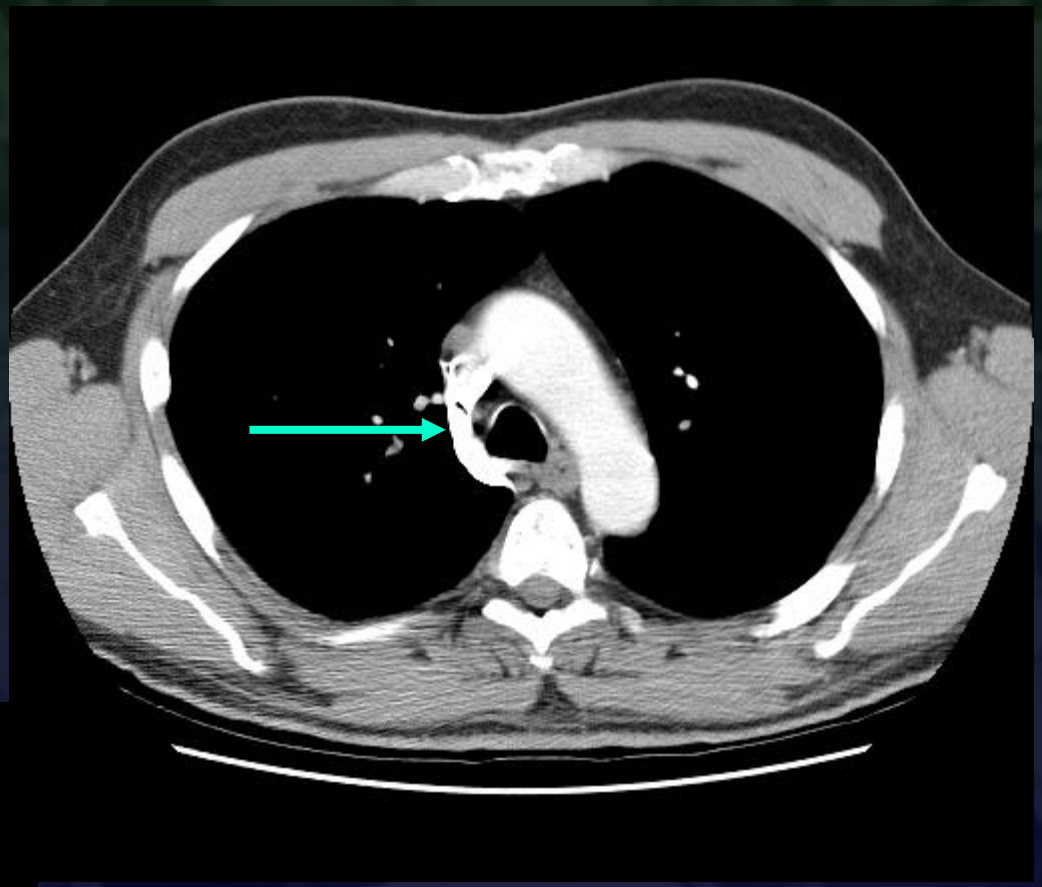


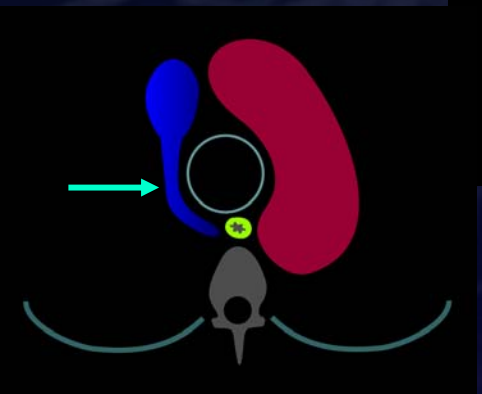
SVC (with mixing artifact)



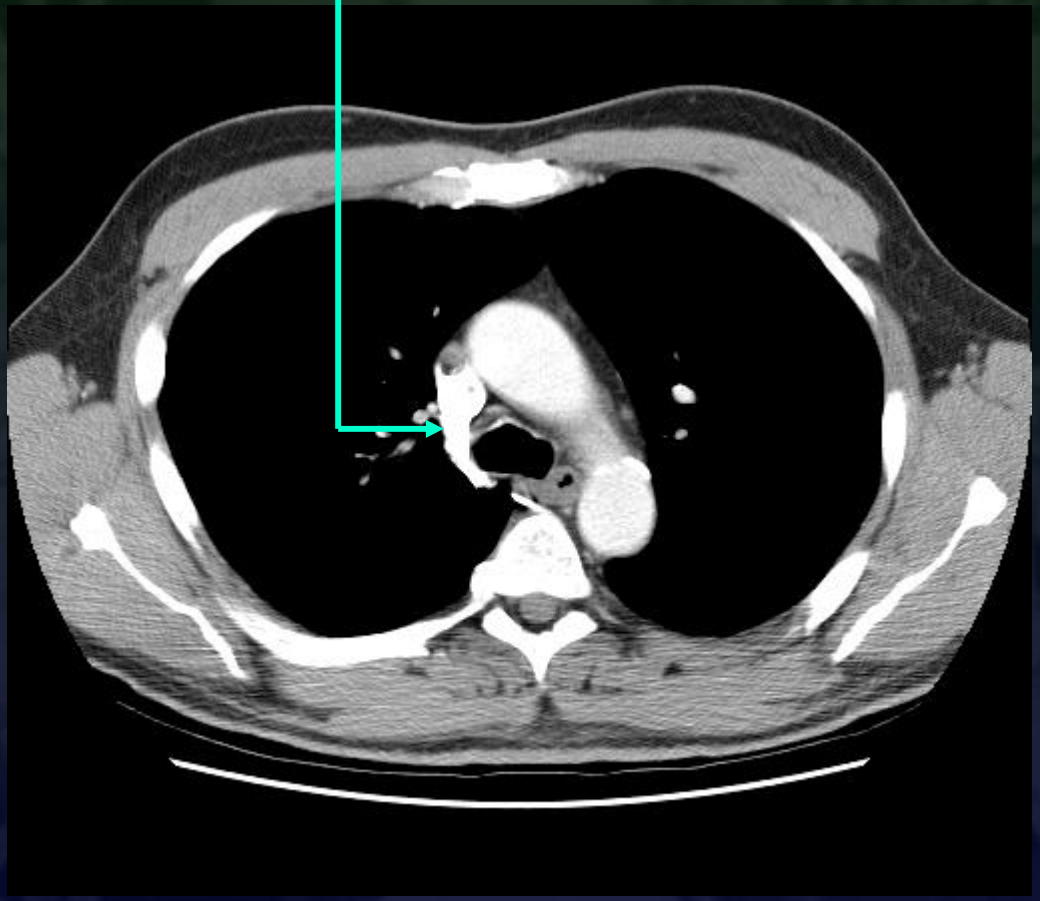
Azygos Vein

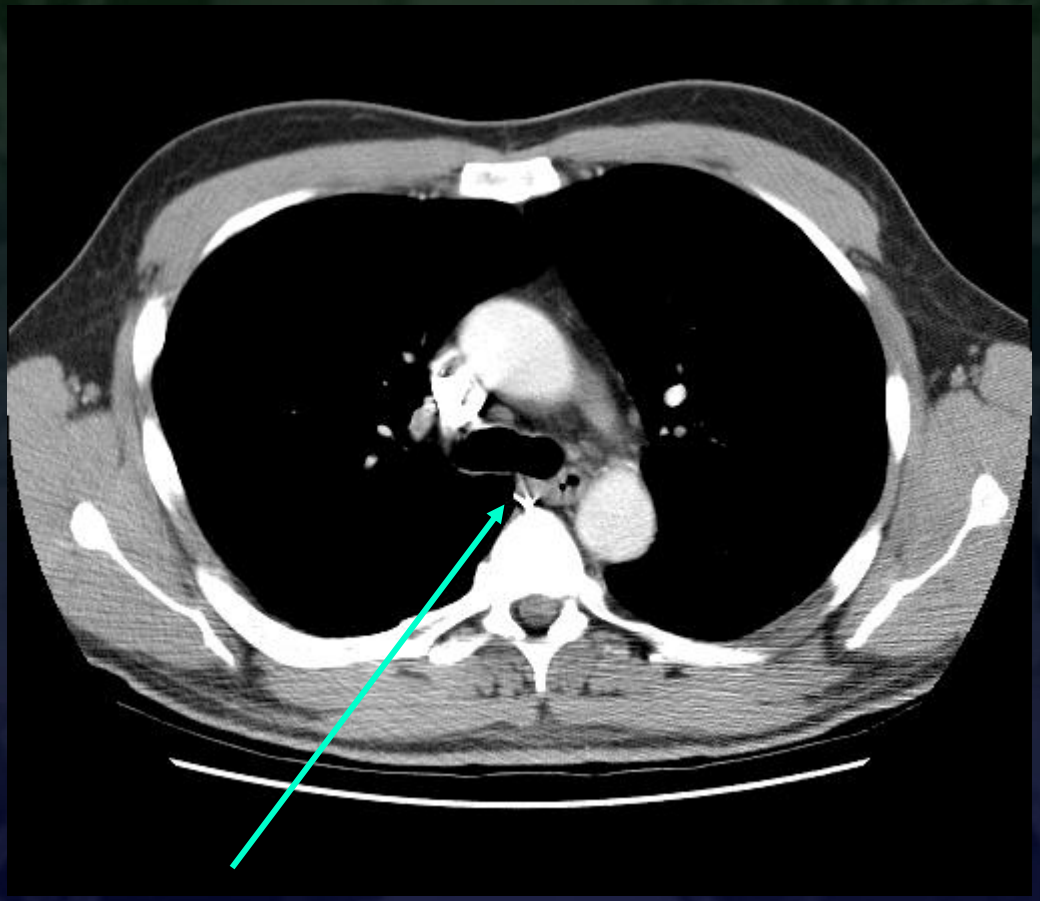
- C-shaped configuration
- contrast reflux is seen in this patient, resulting in enhancement



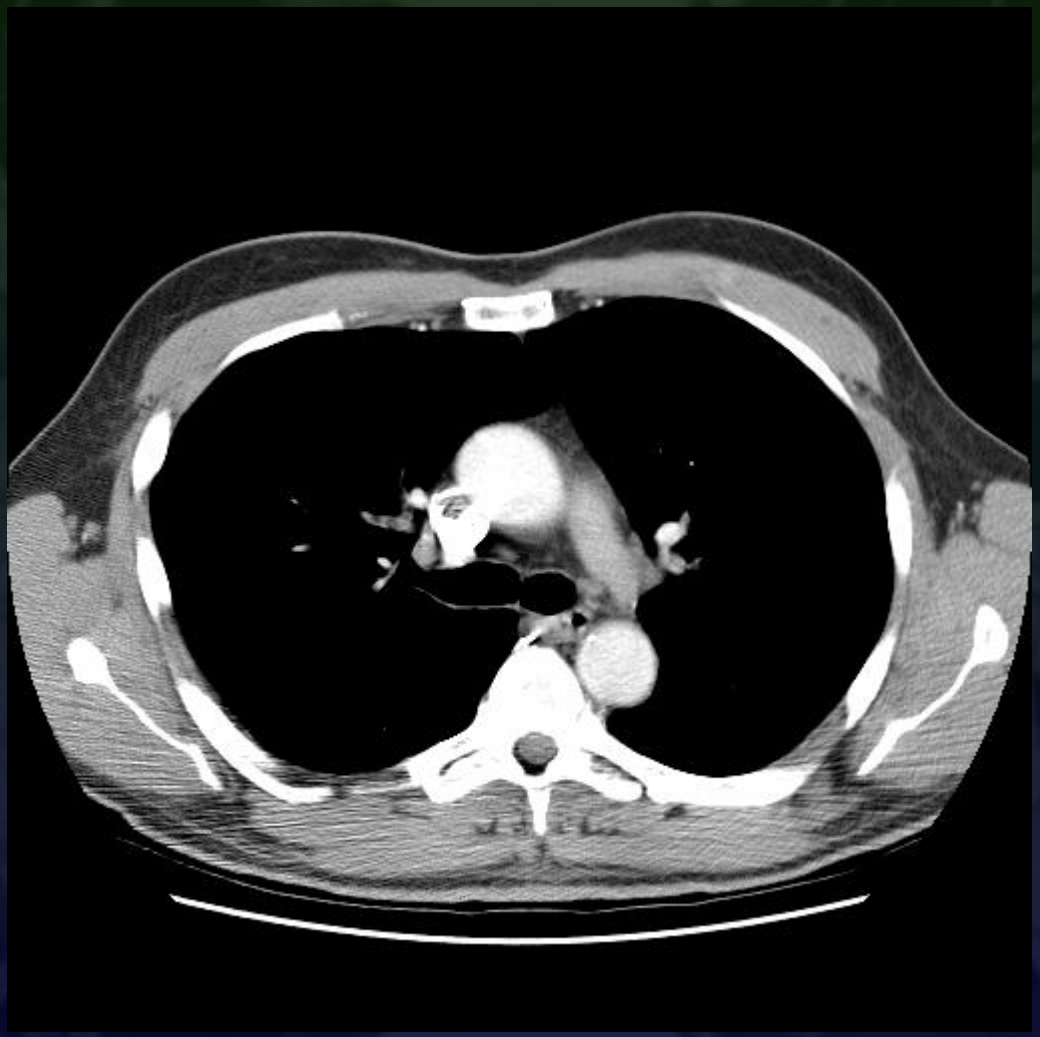


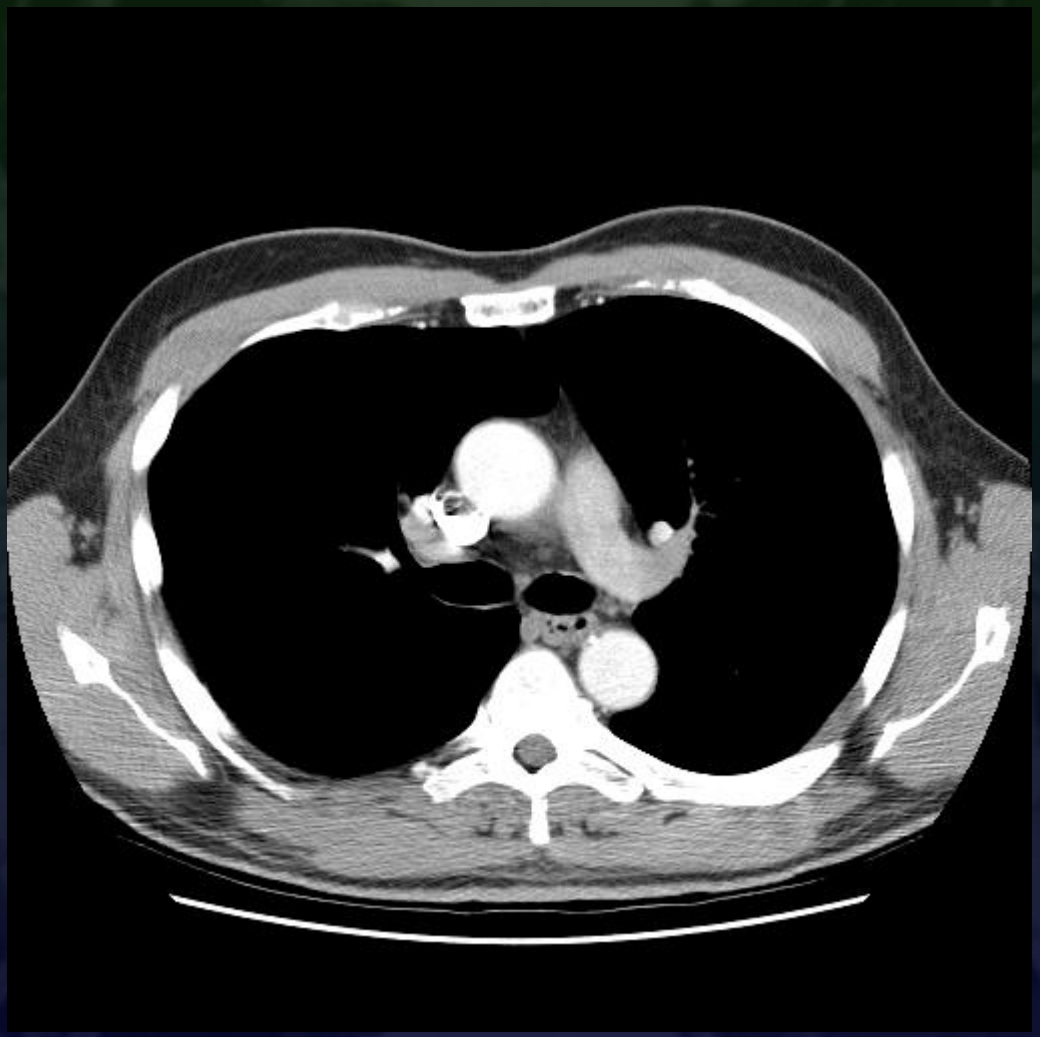
Azygos vein joining SVC



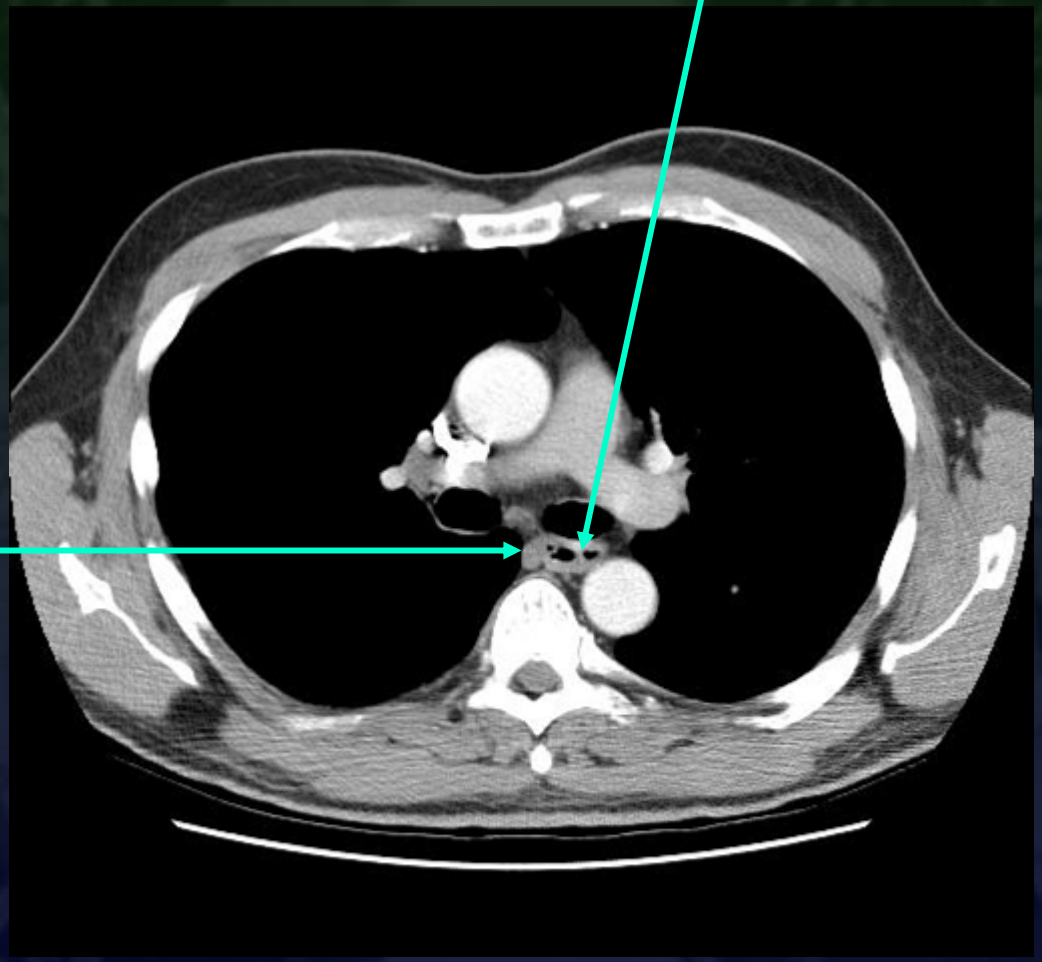


Azygos vein (vertical segment) in posterior mediastinum

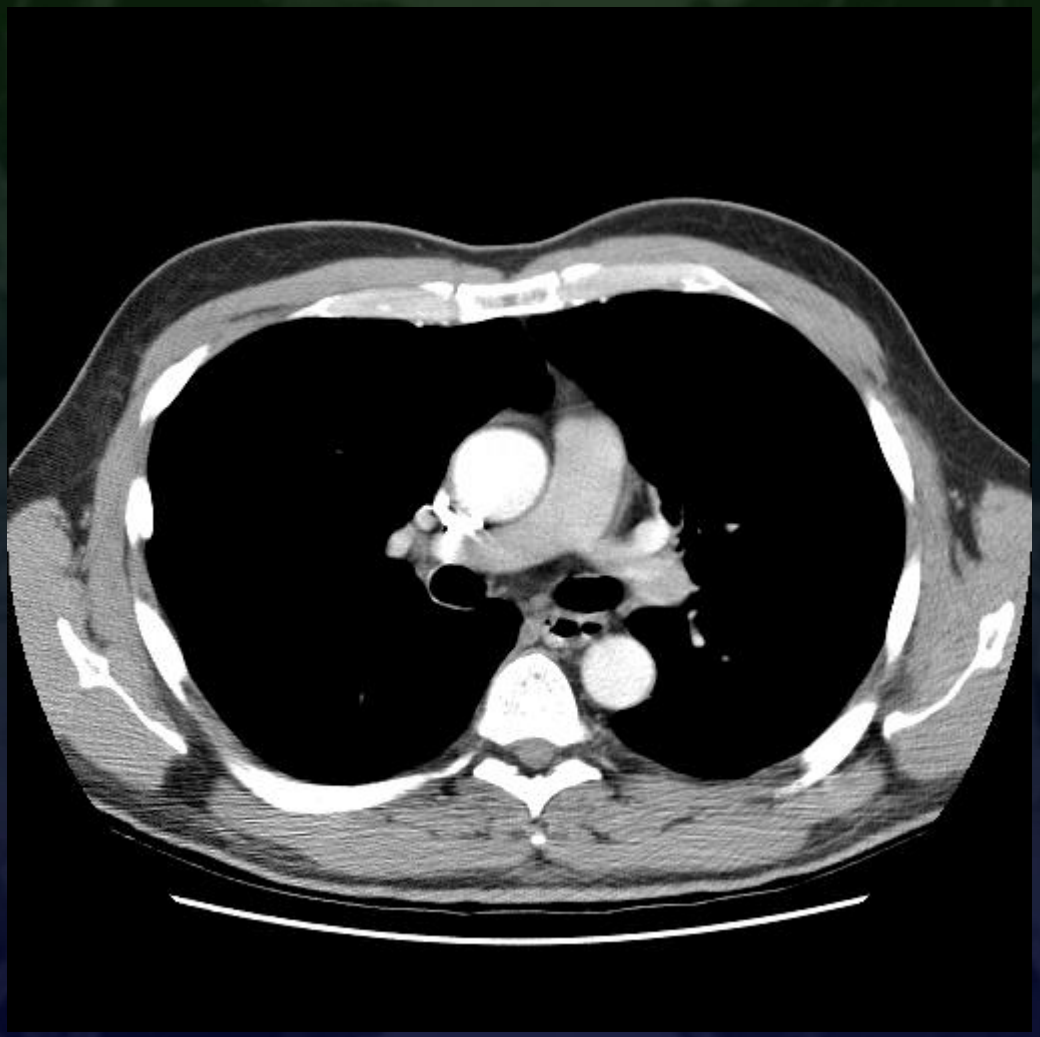




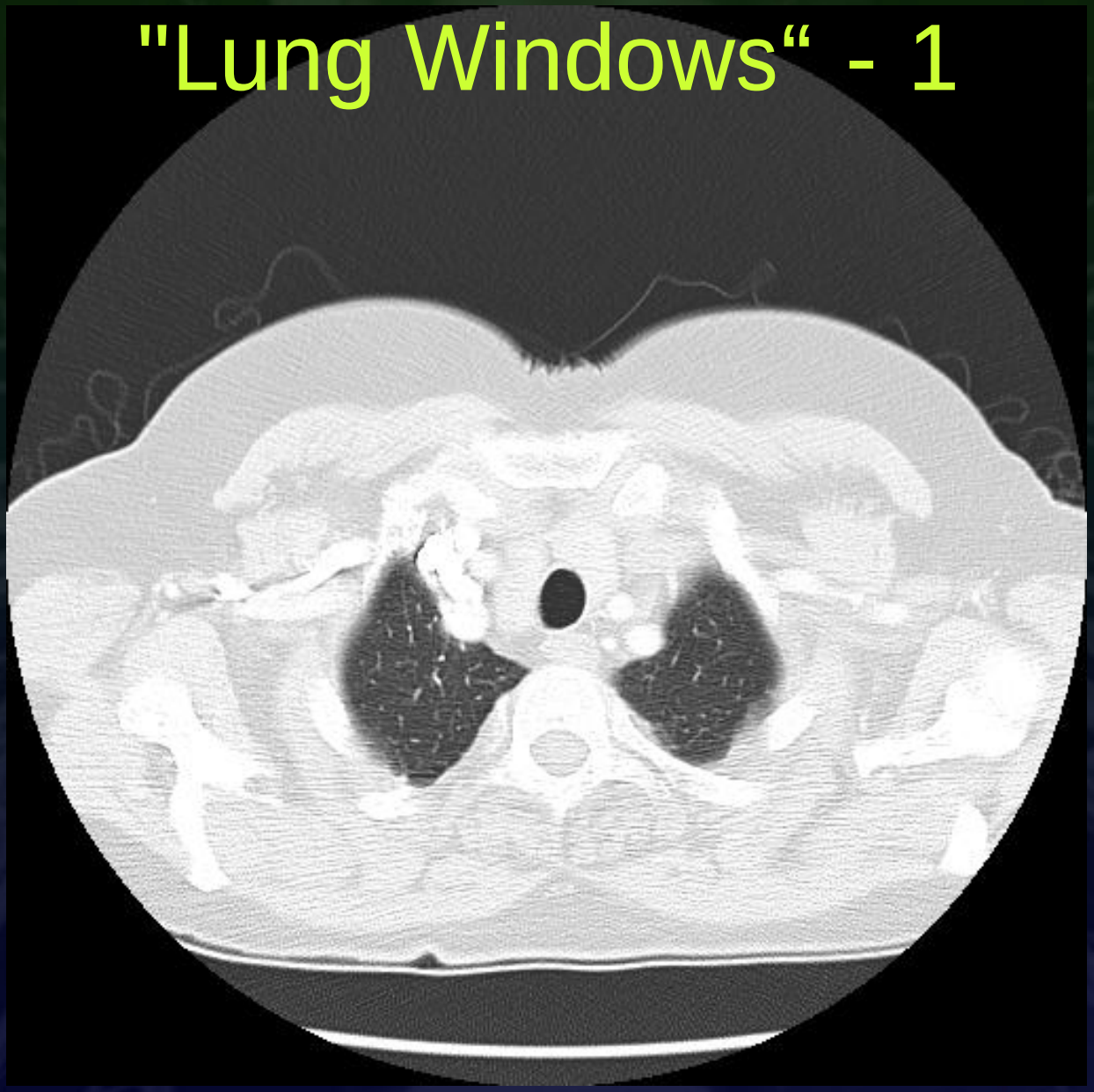
Oesophagus

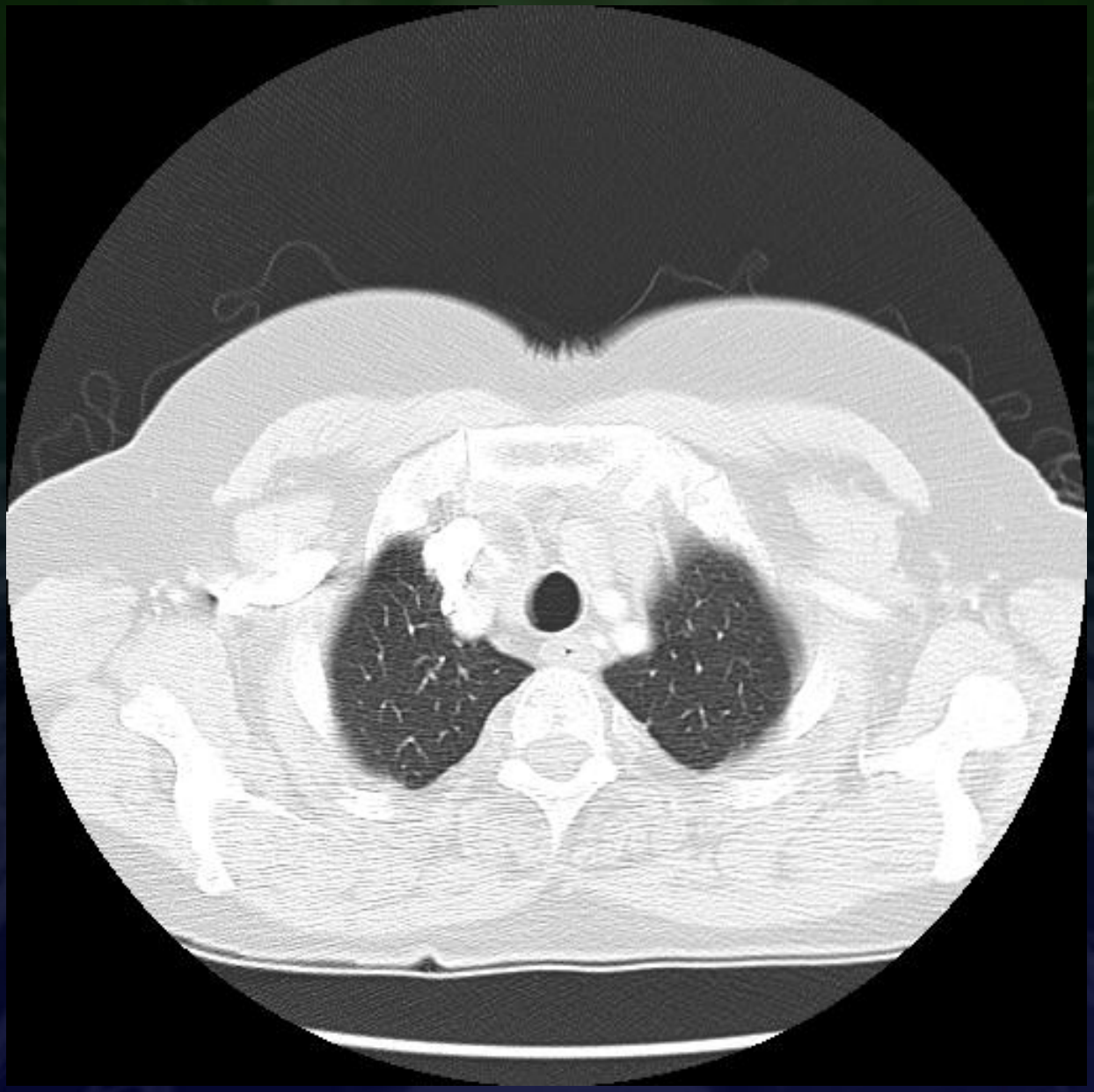


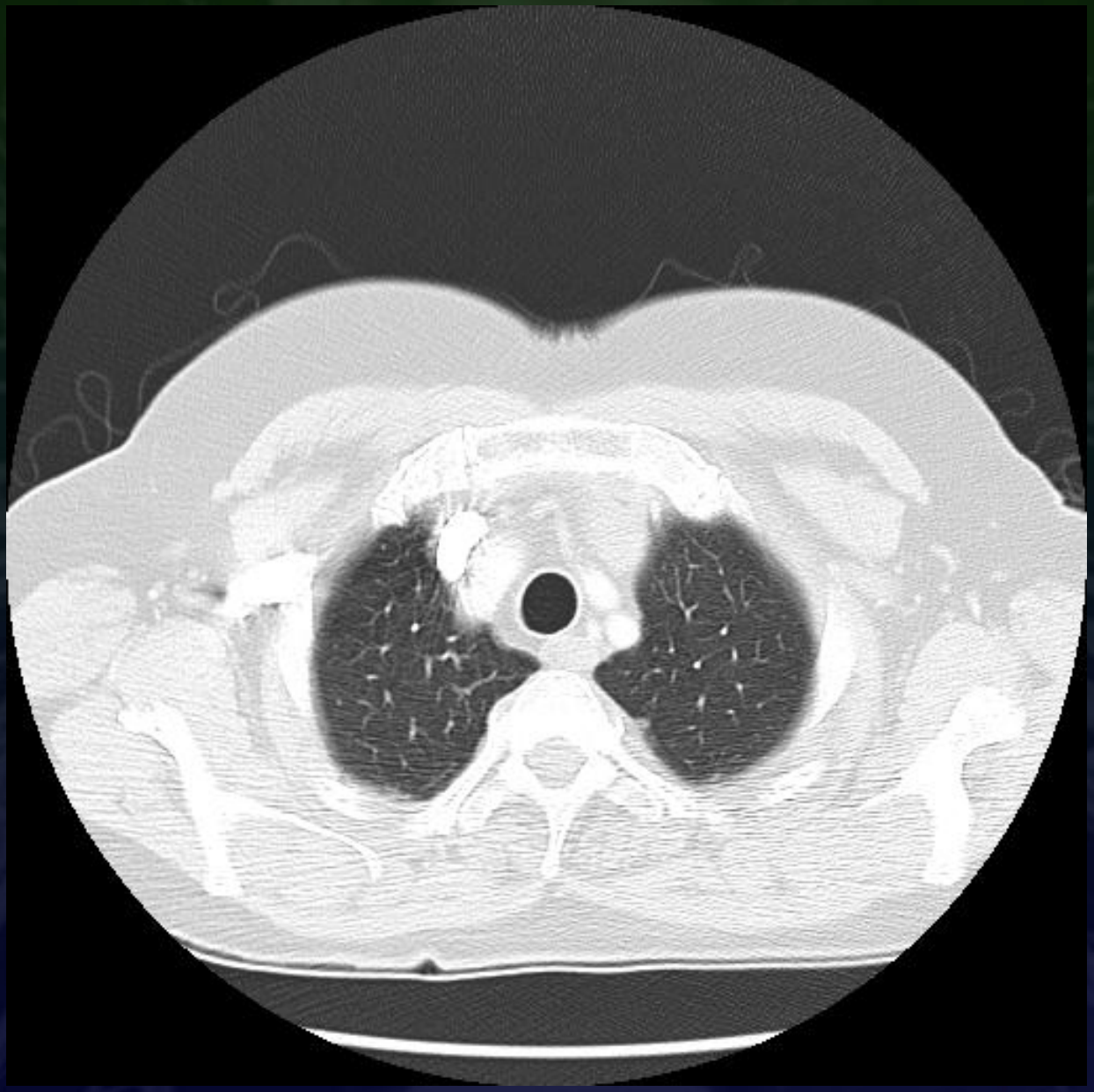
Azygos vein

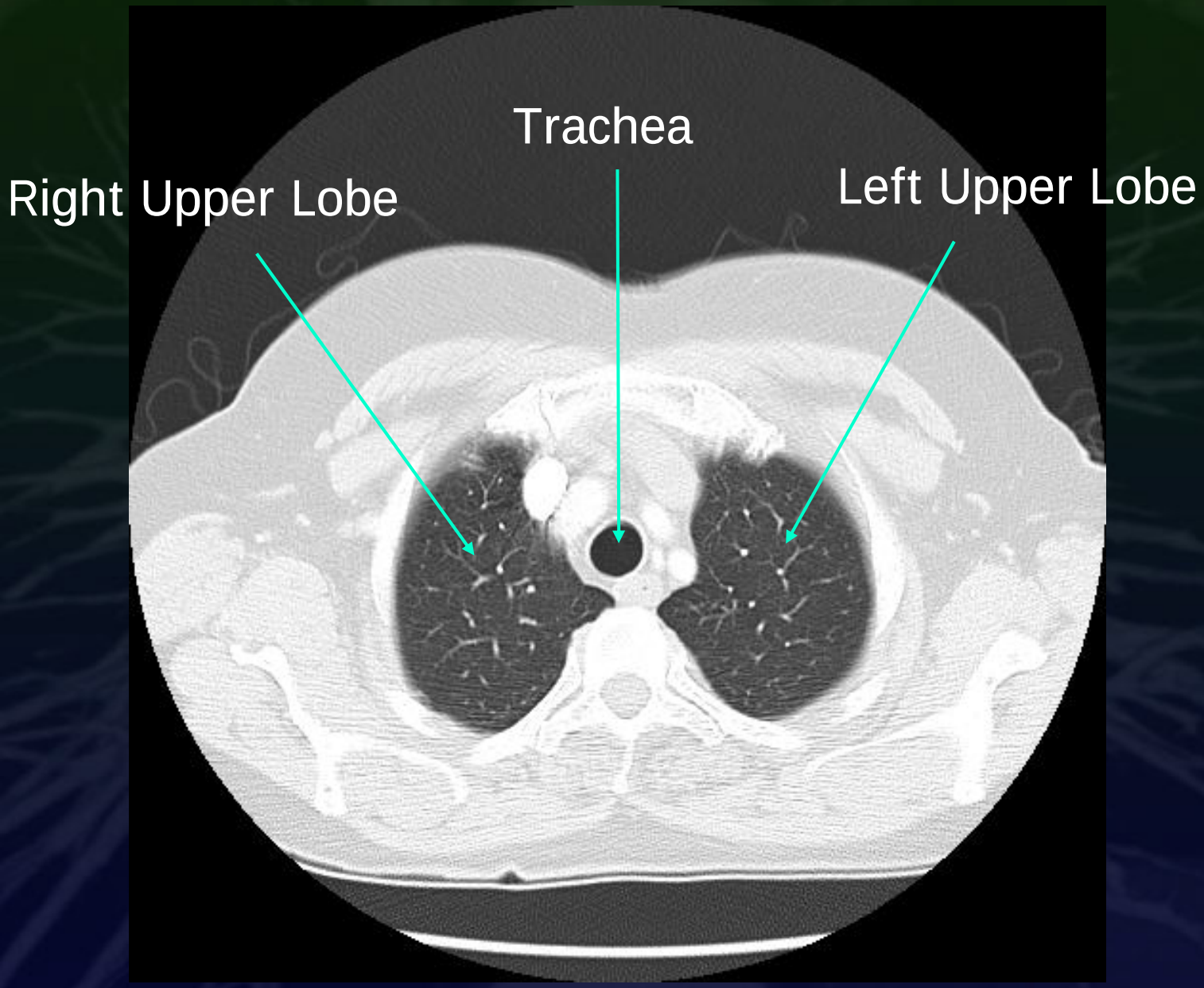


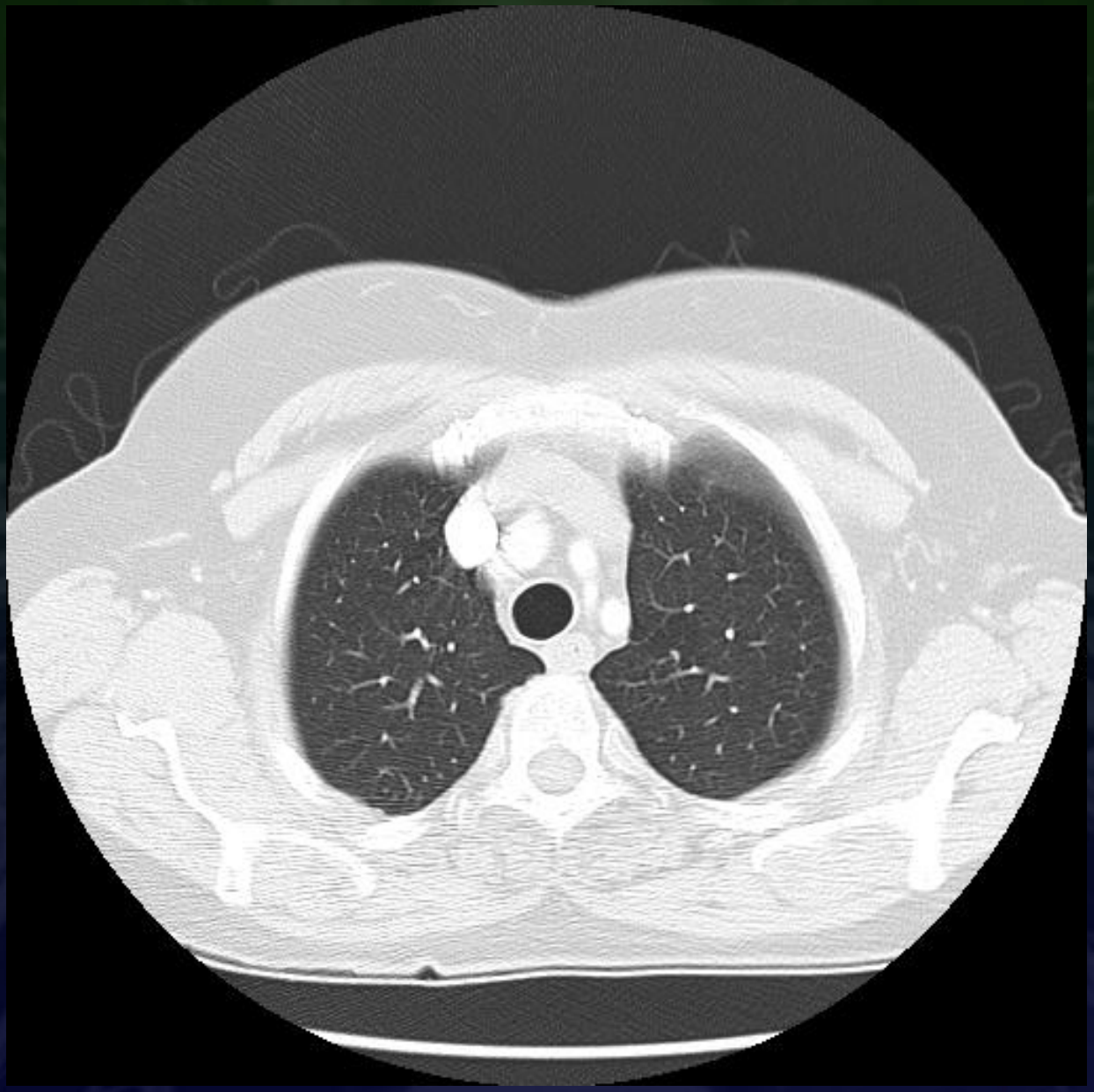
"Lung Windows“ - 1

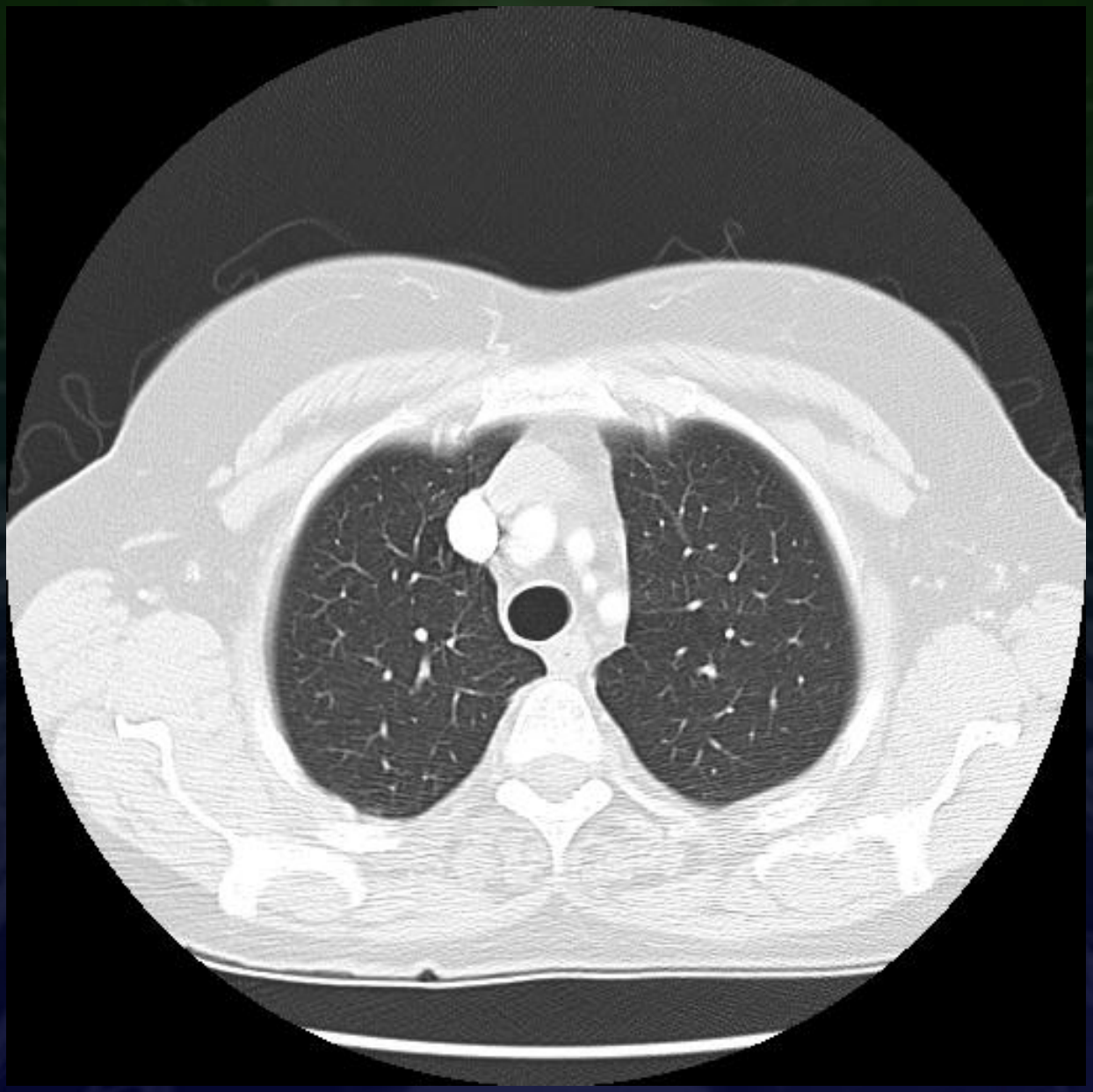


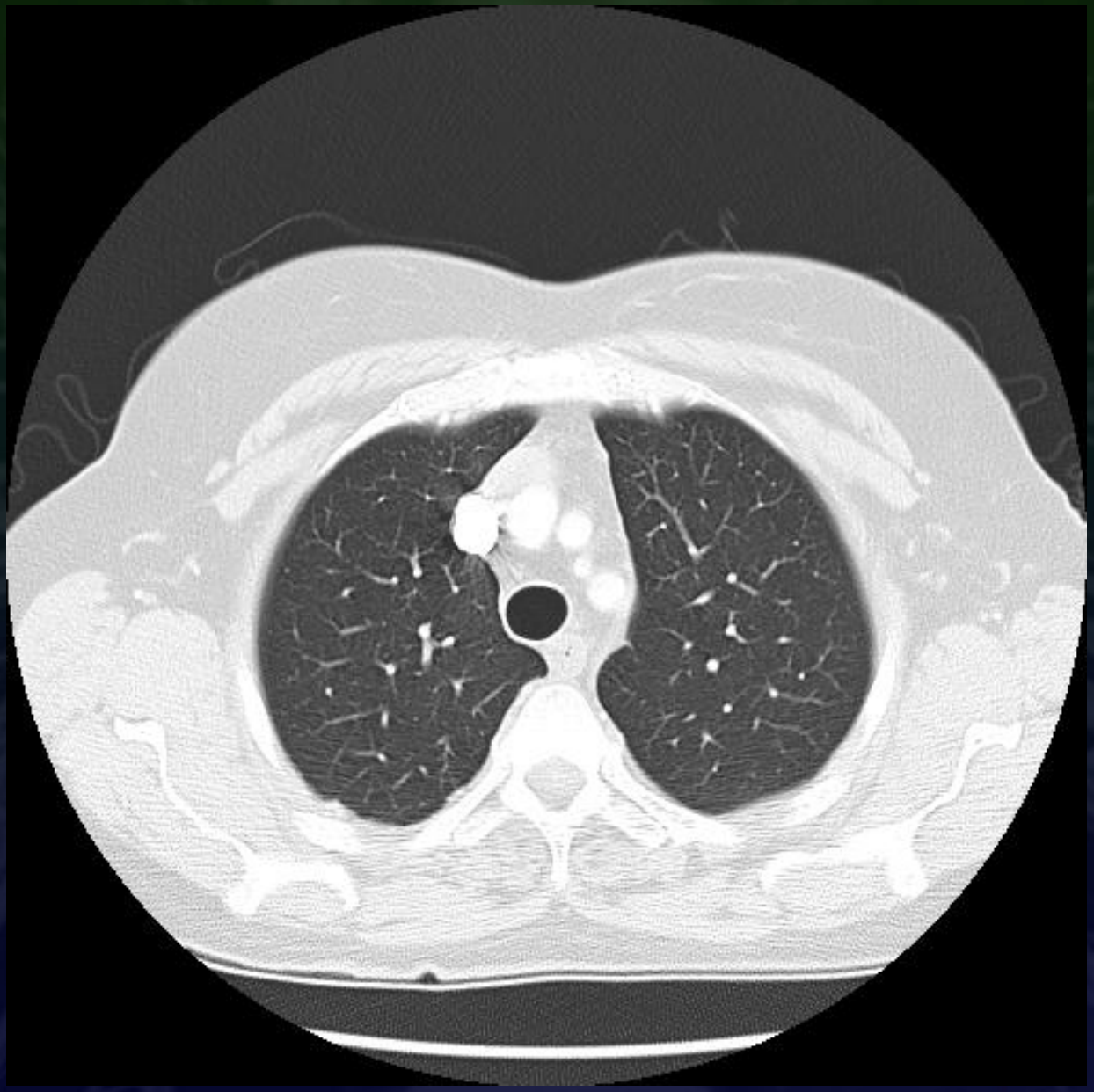


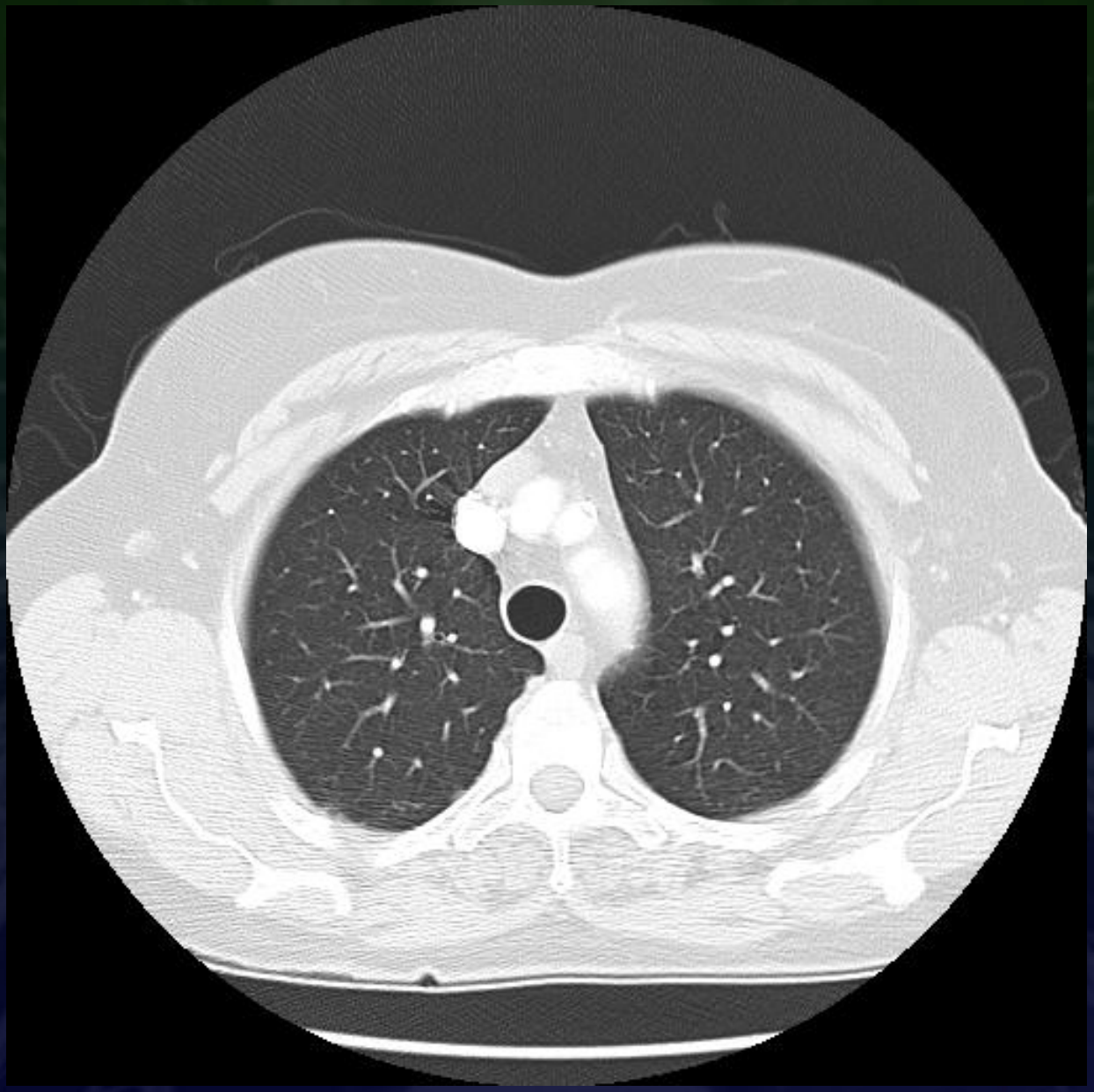


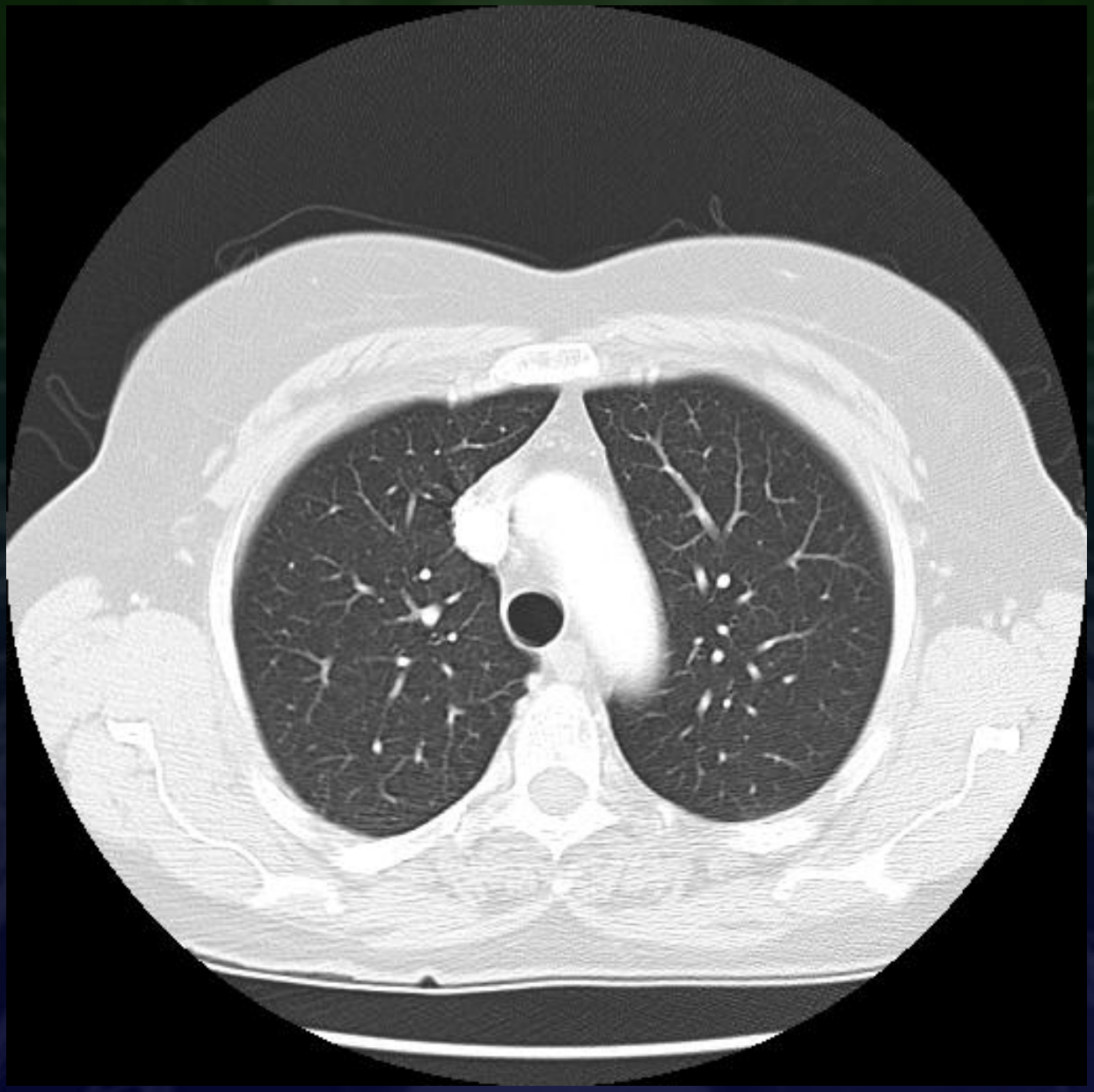

Trachea
Right Upper Lobe
Left Upper Lobe

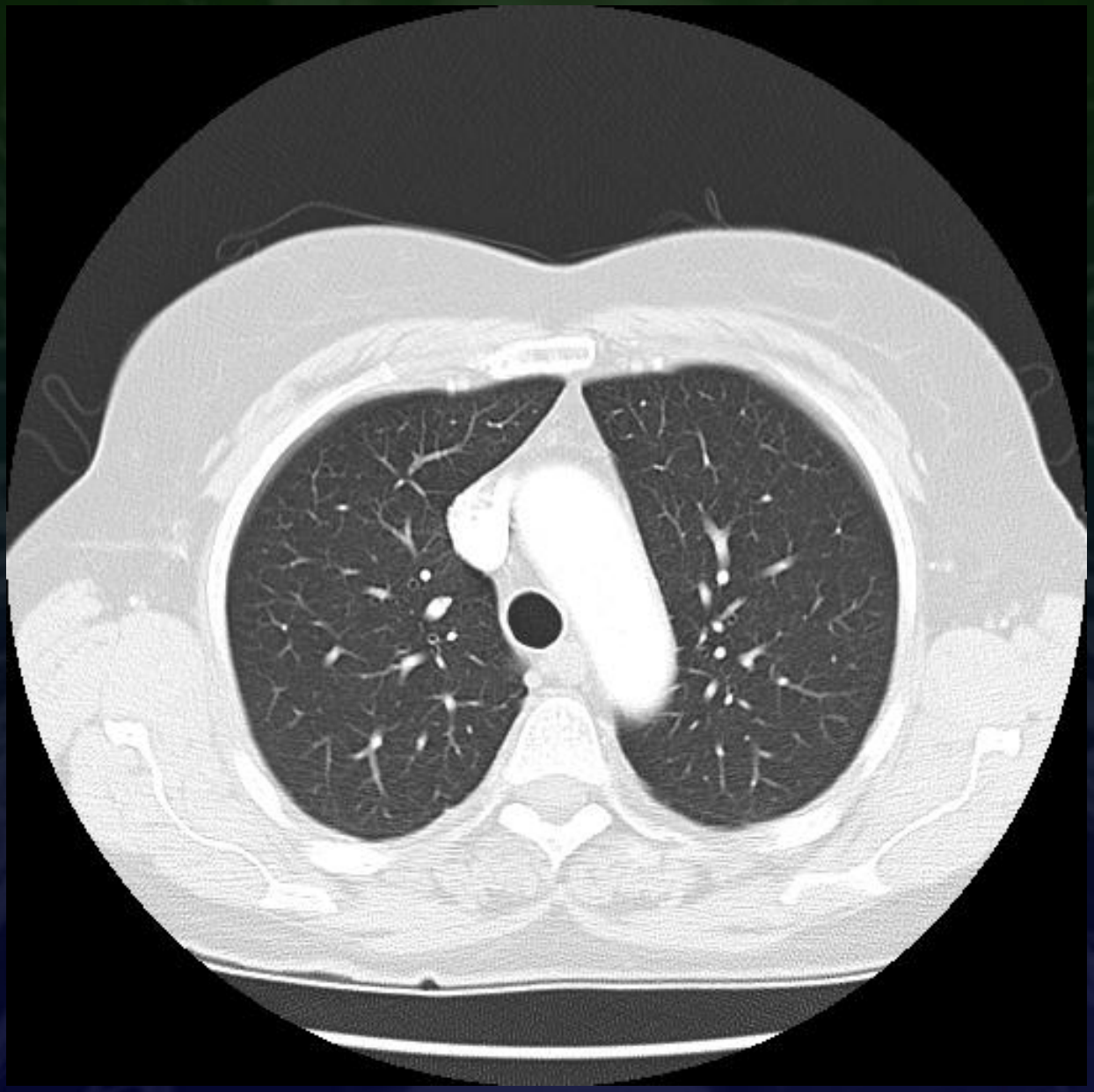


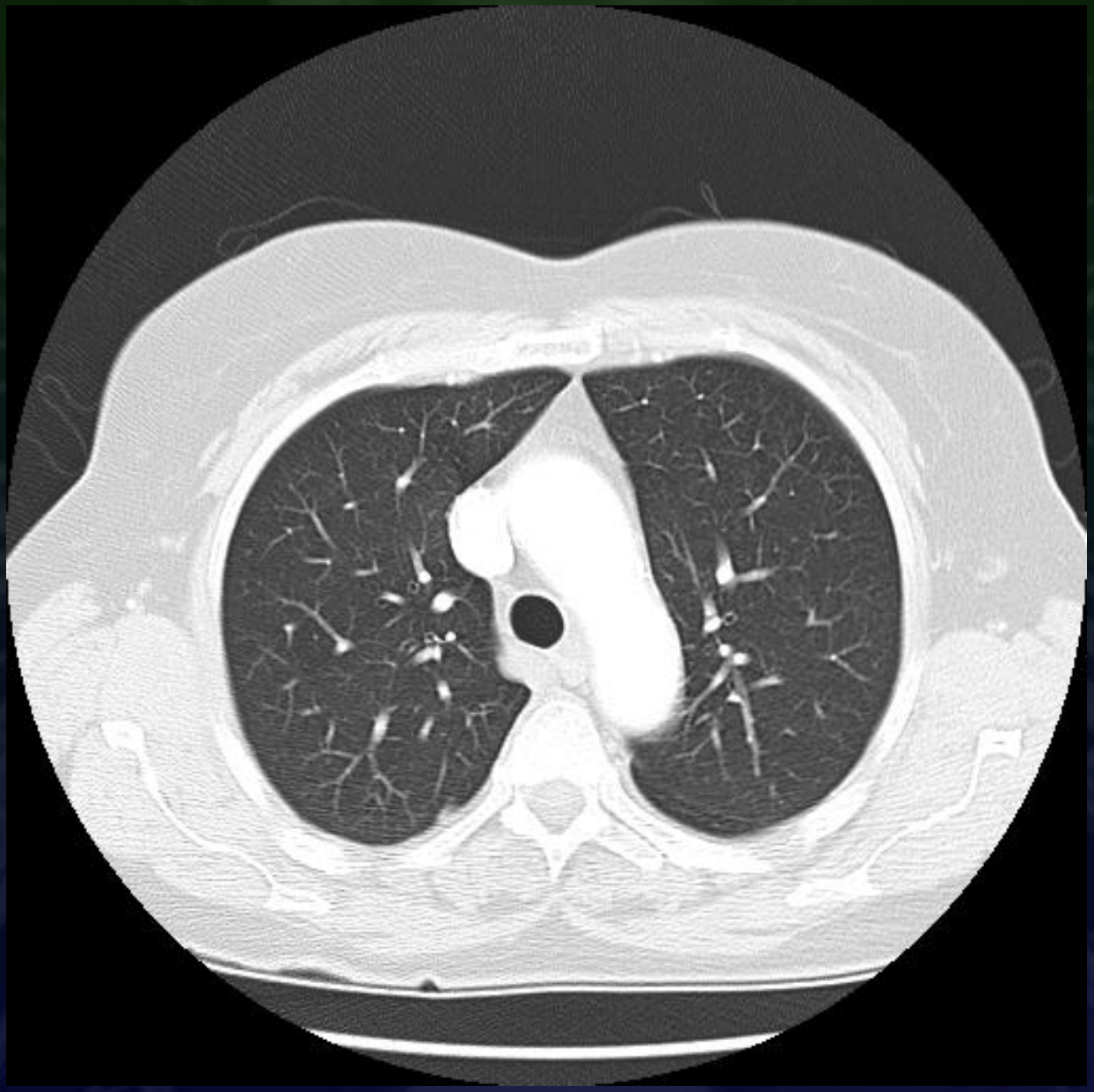


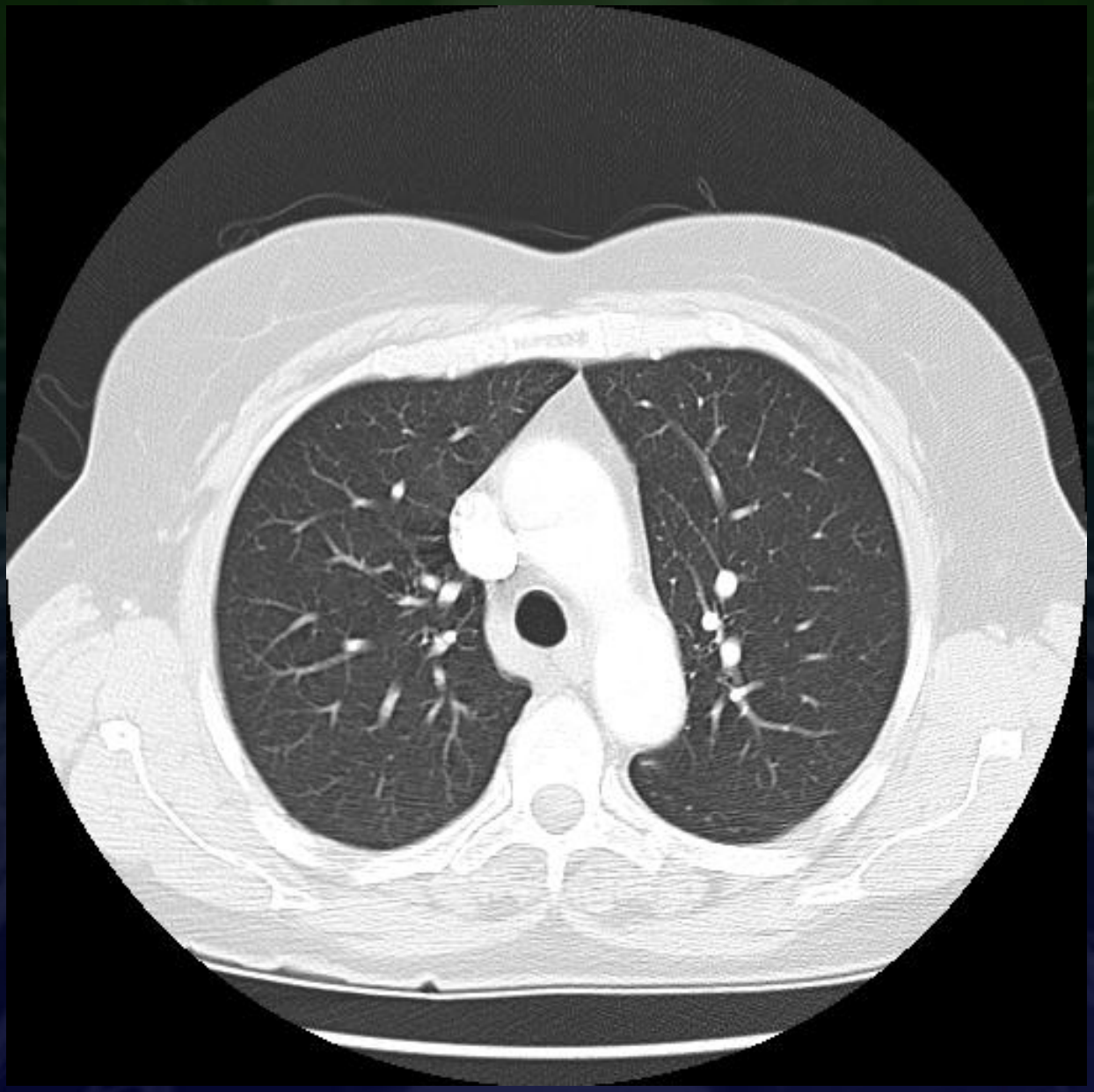


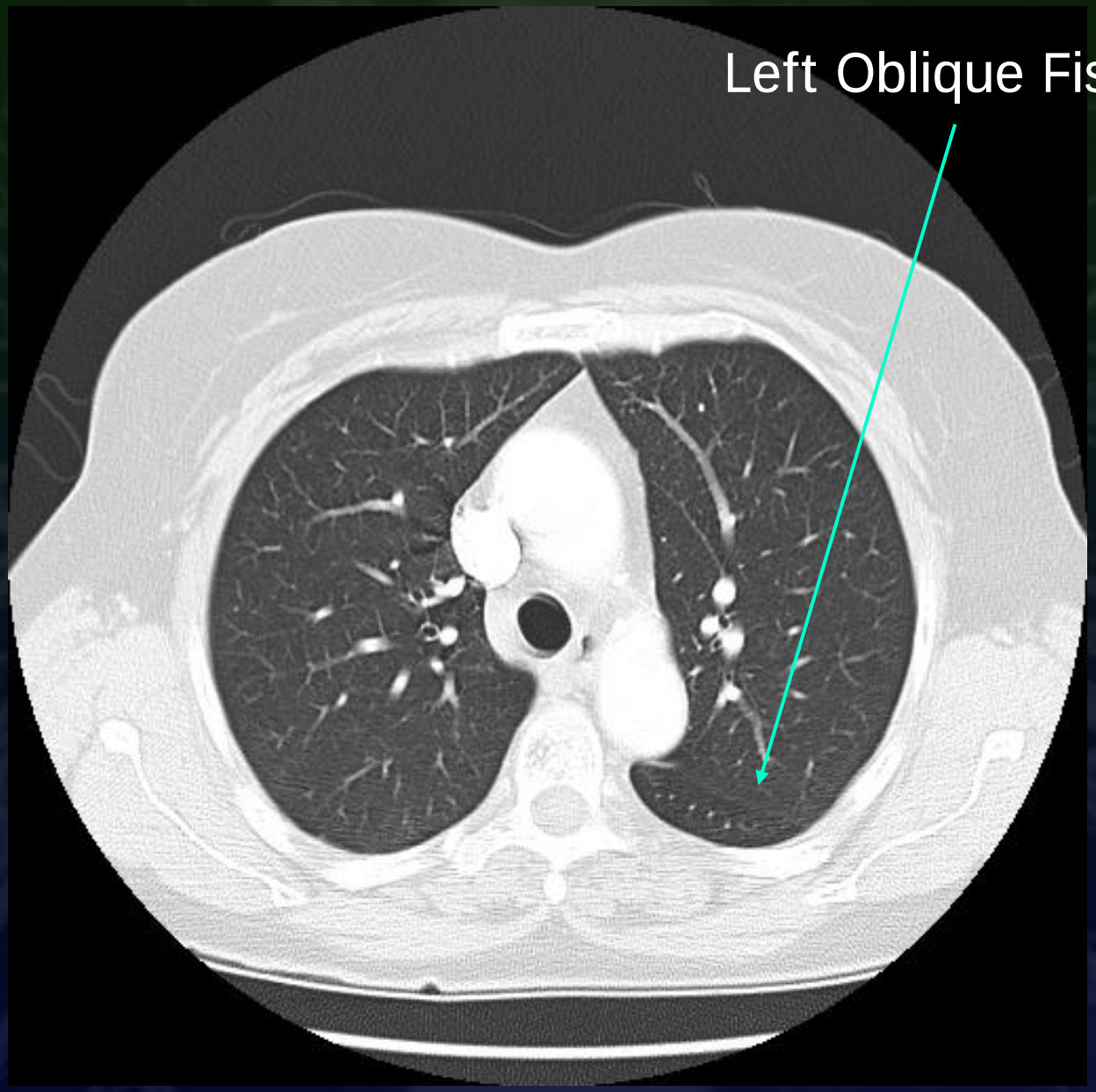


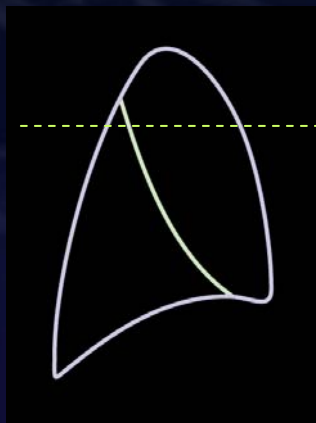


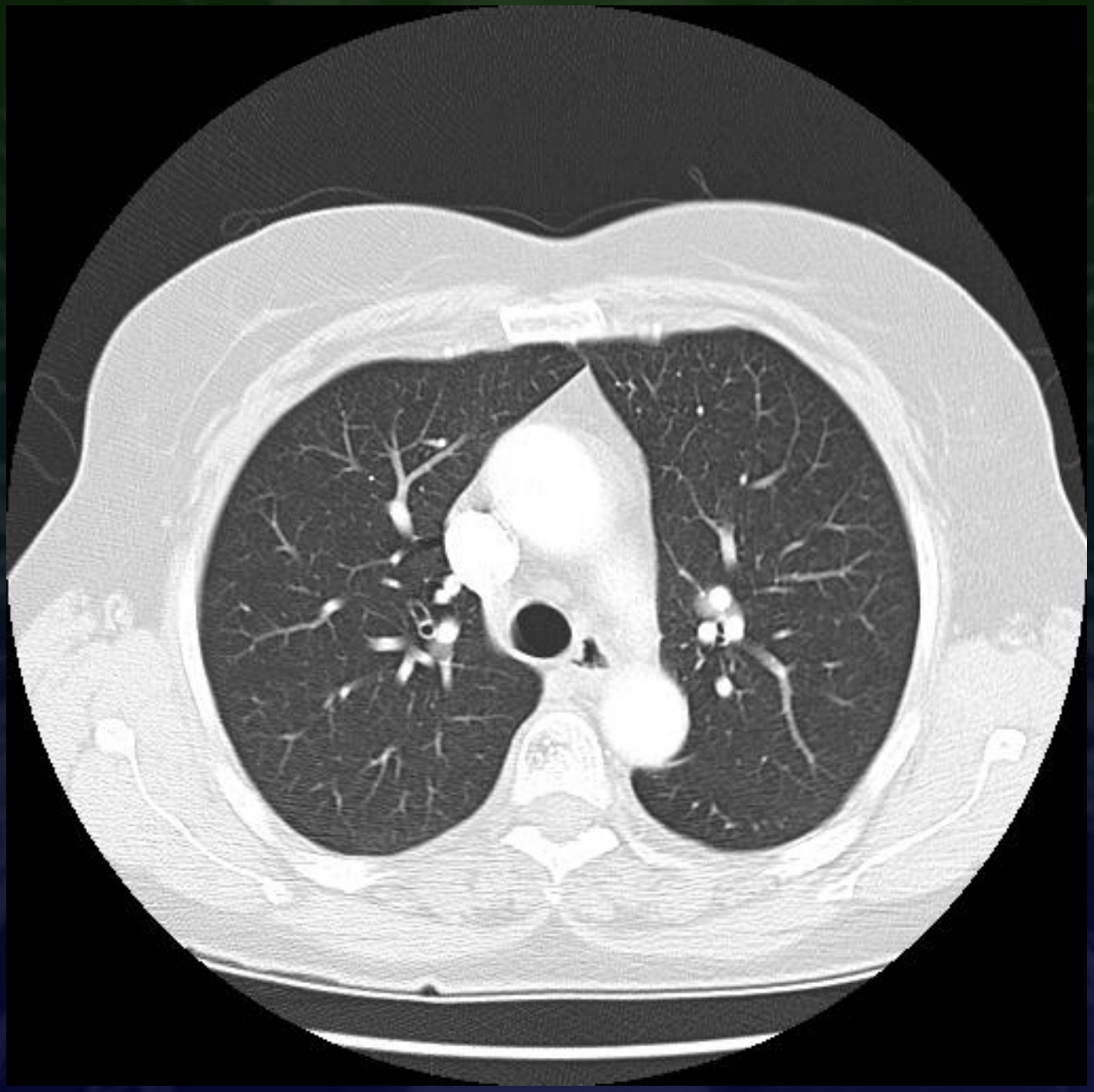


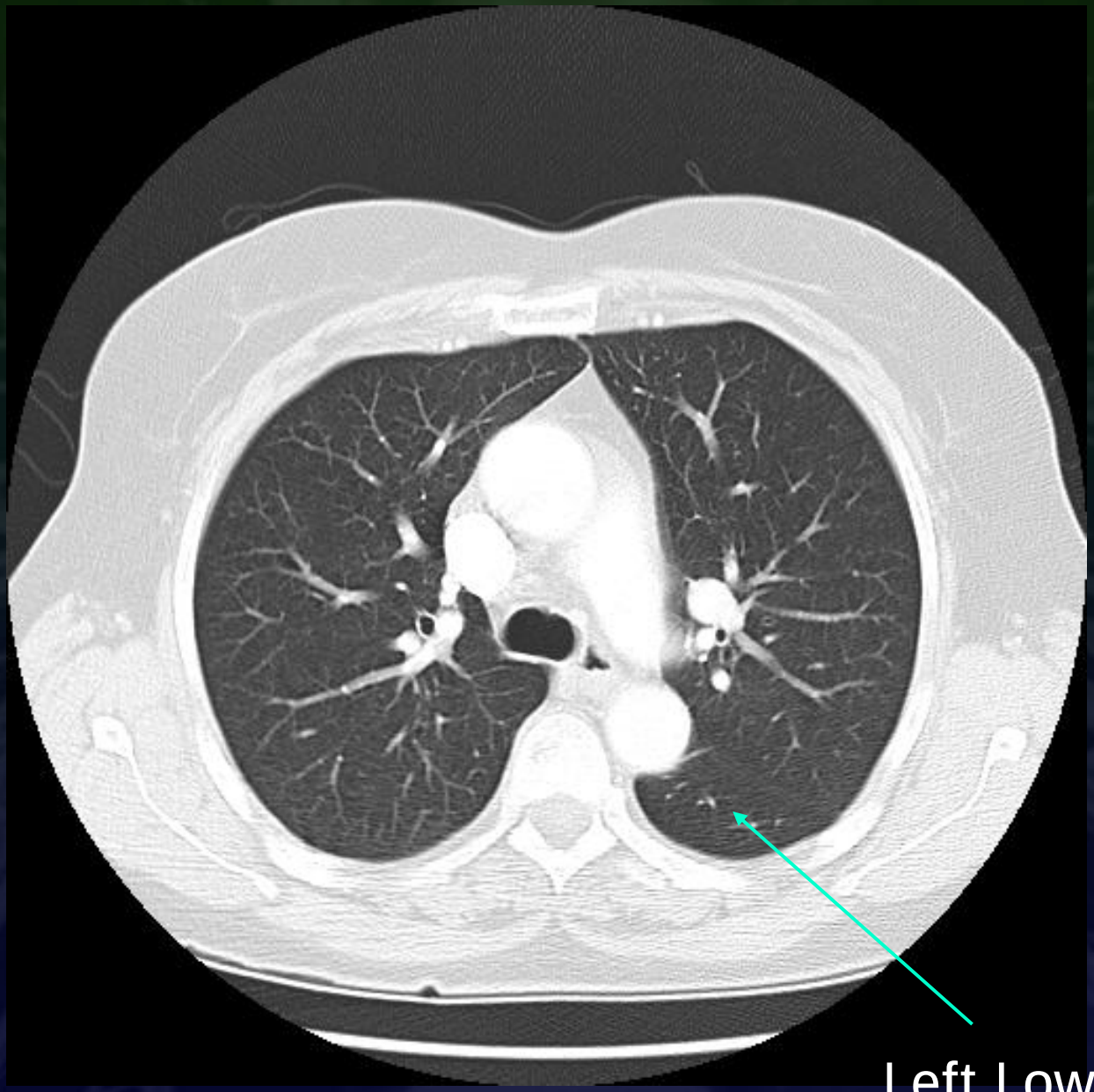


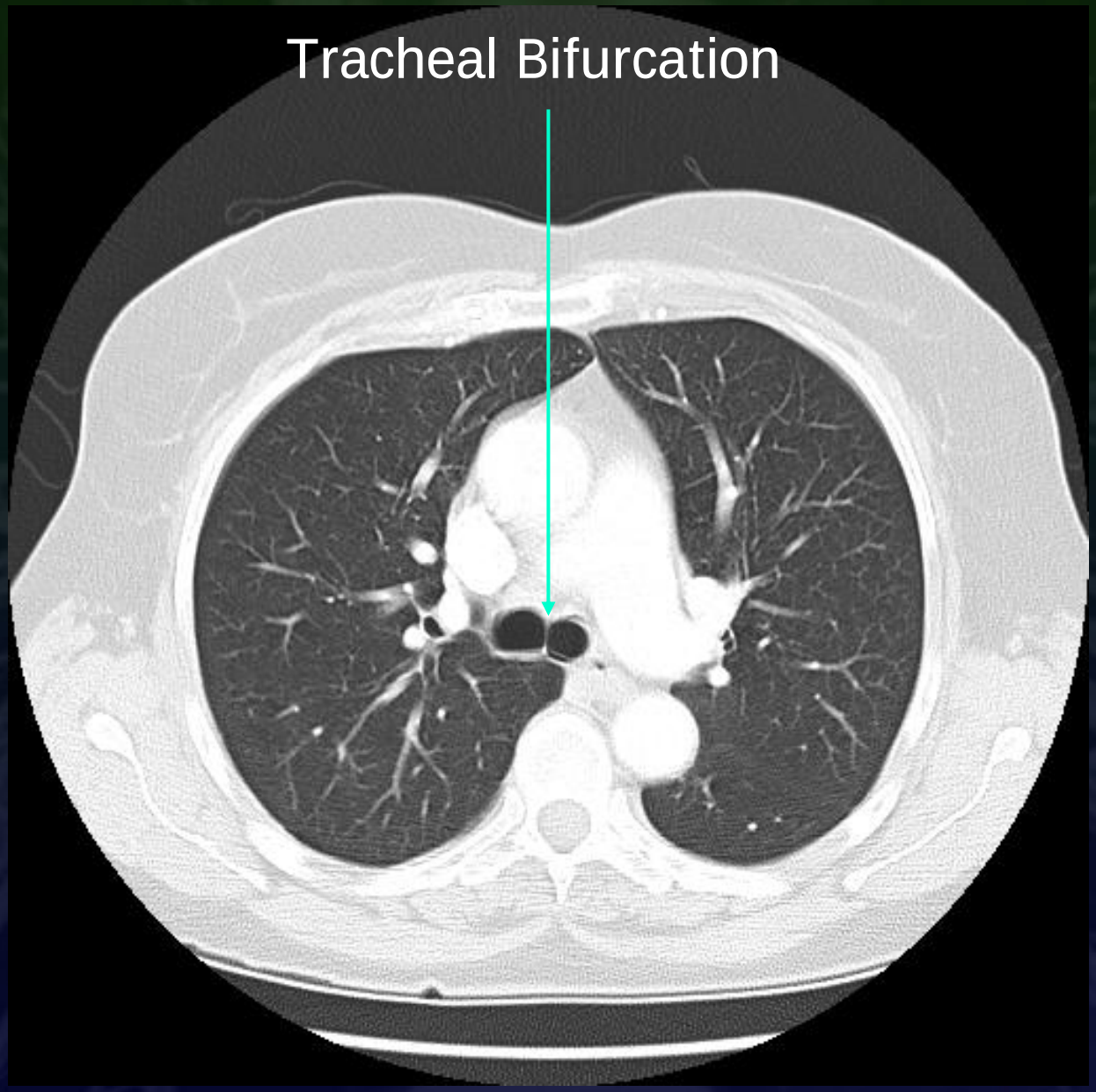


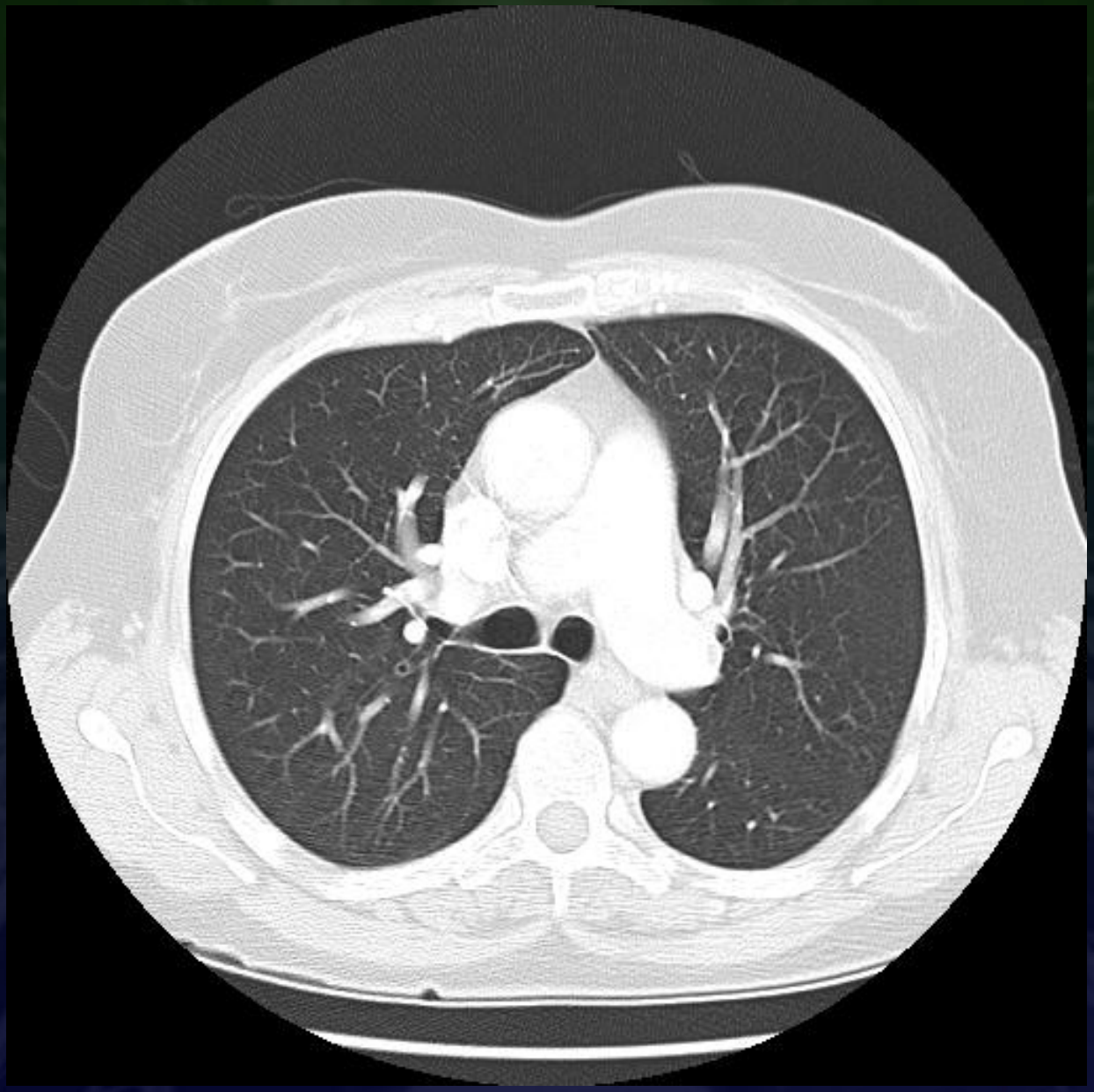

Left Oblique Fissure





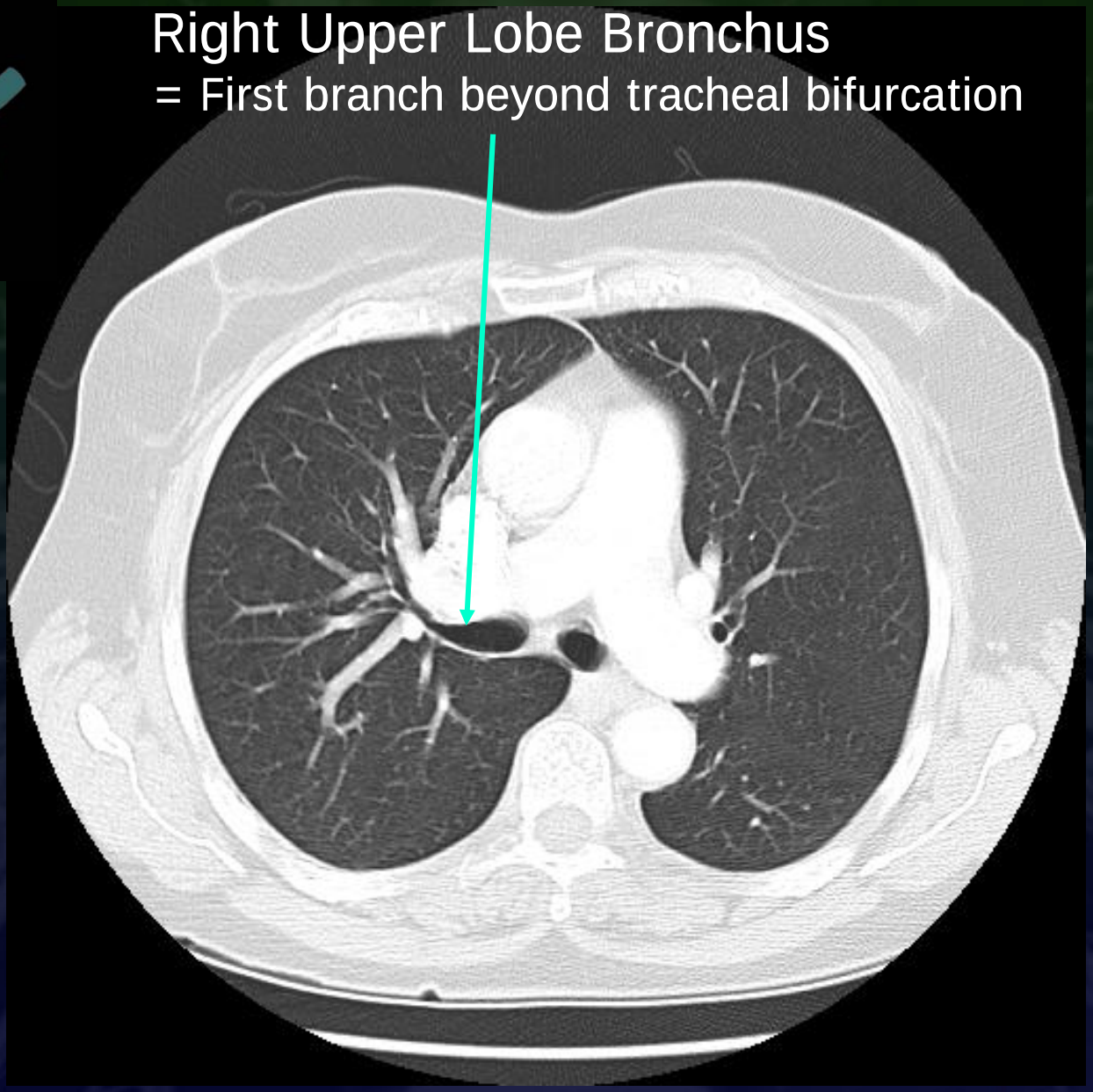

Left Lower Lobe

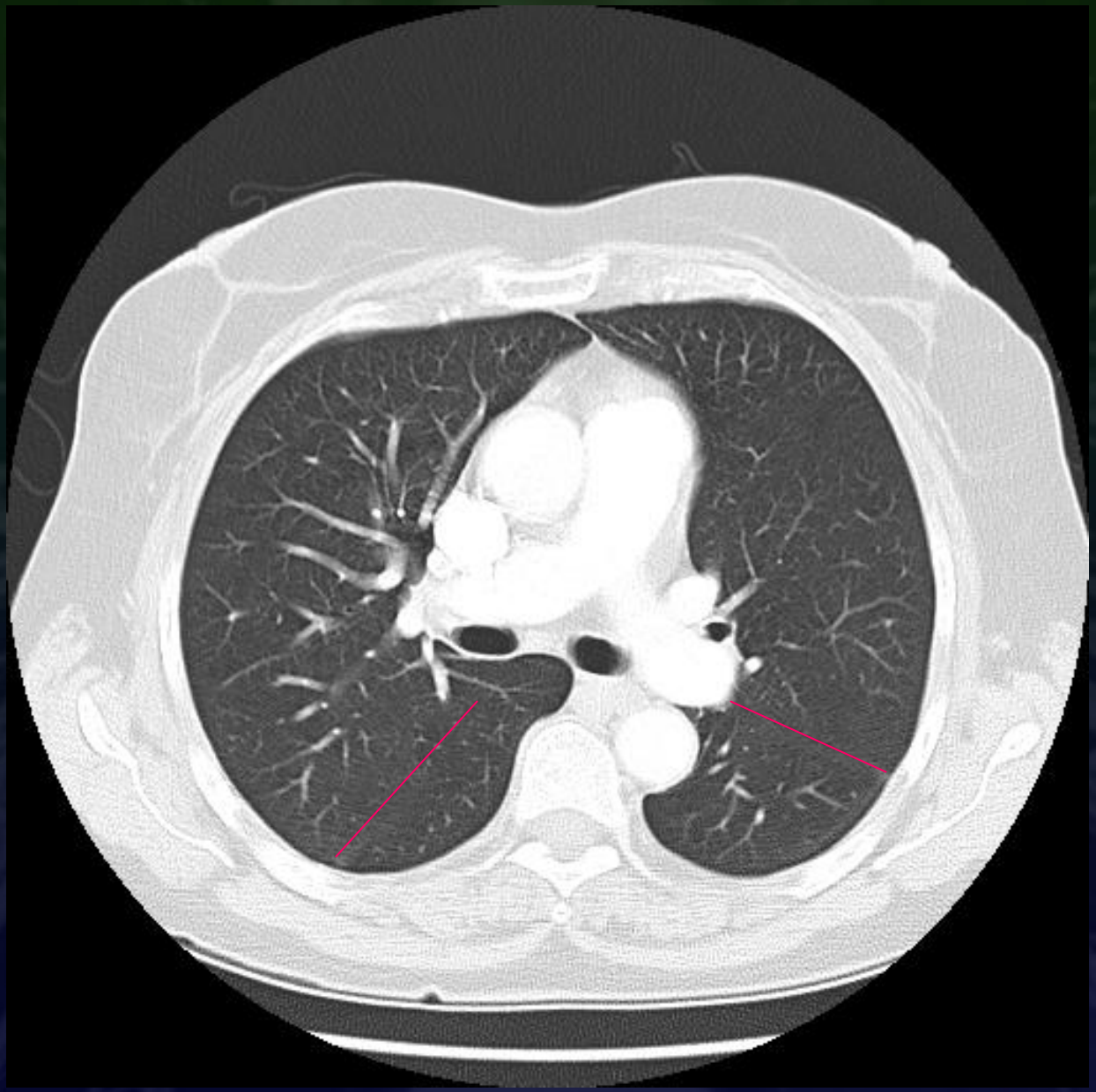

Tracheal Bifurcation



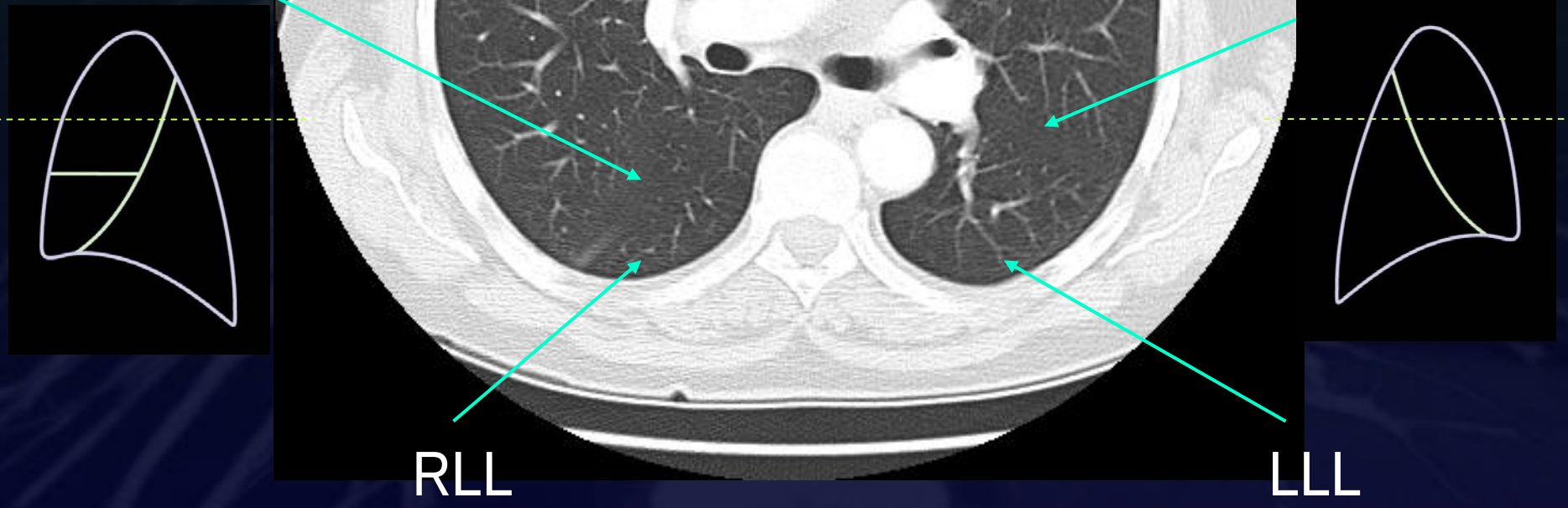
Right Upper Lobe Bronchus

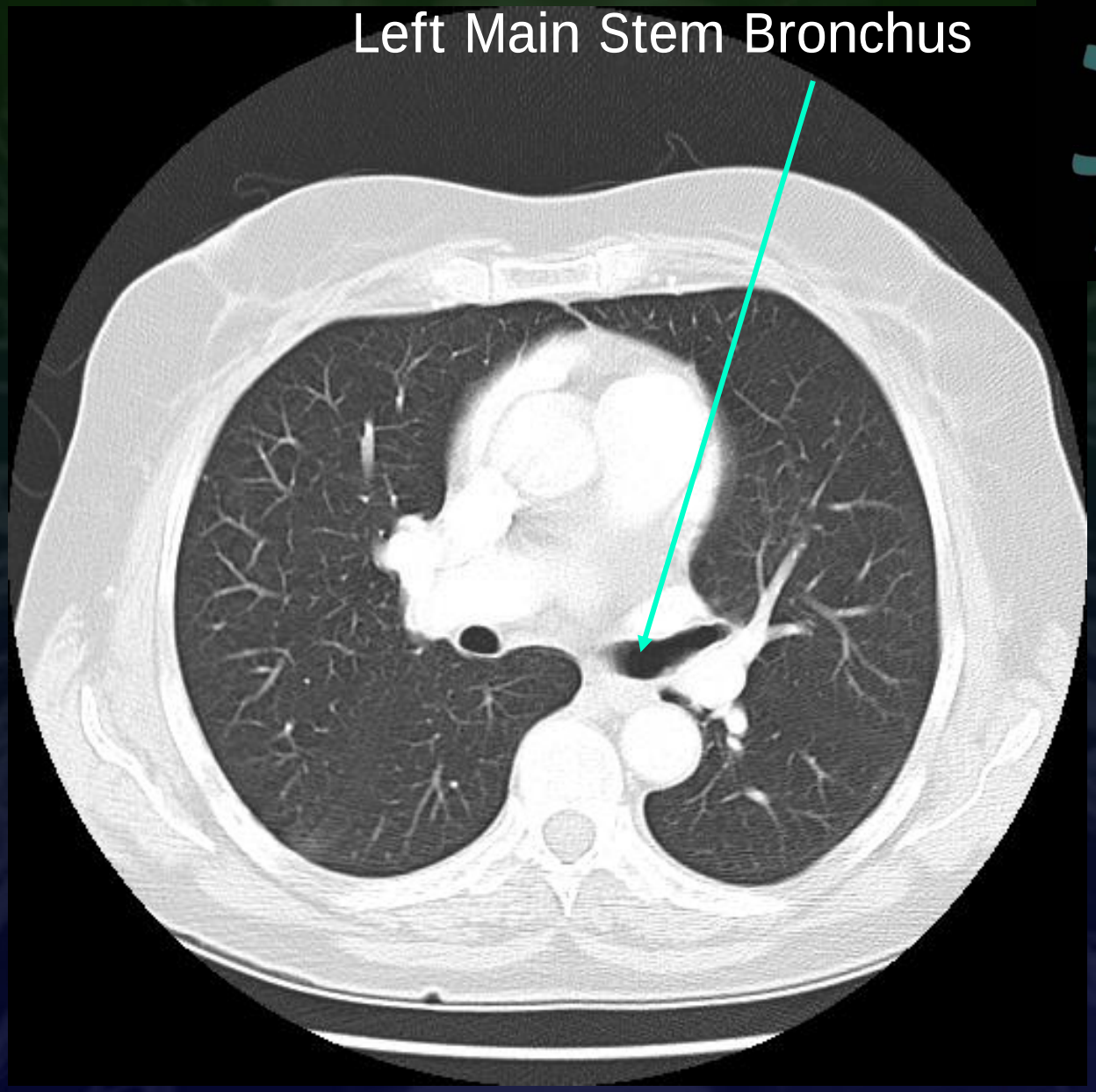
= First branch beyond tracheal bifurcation



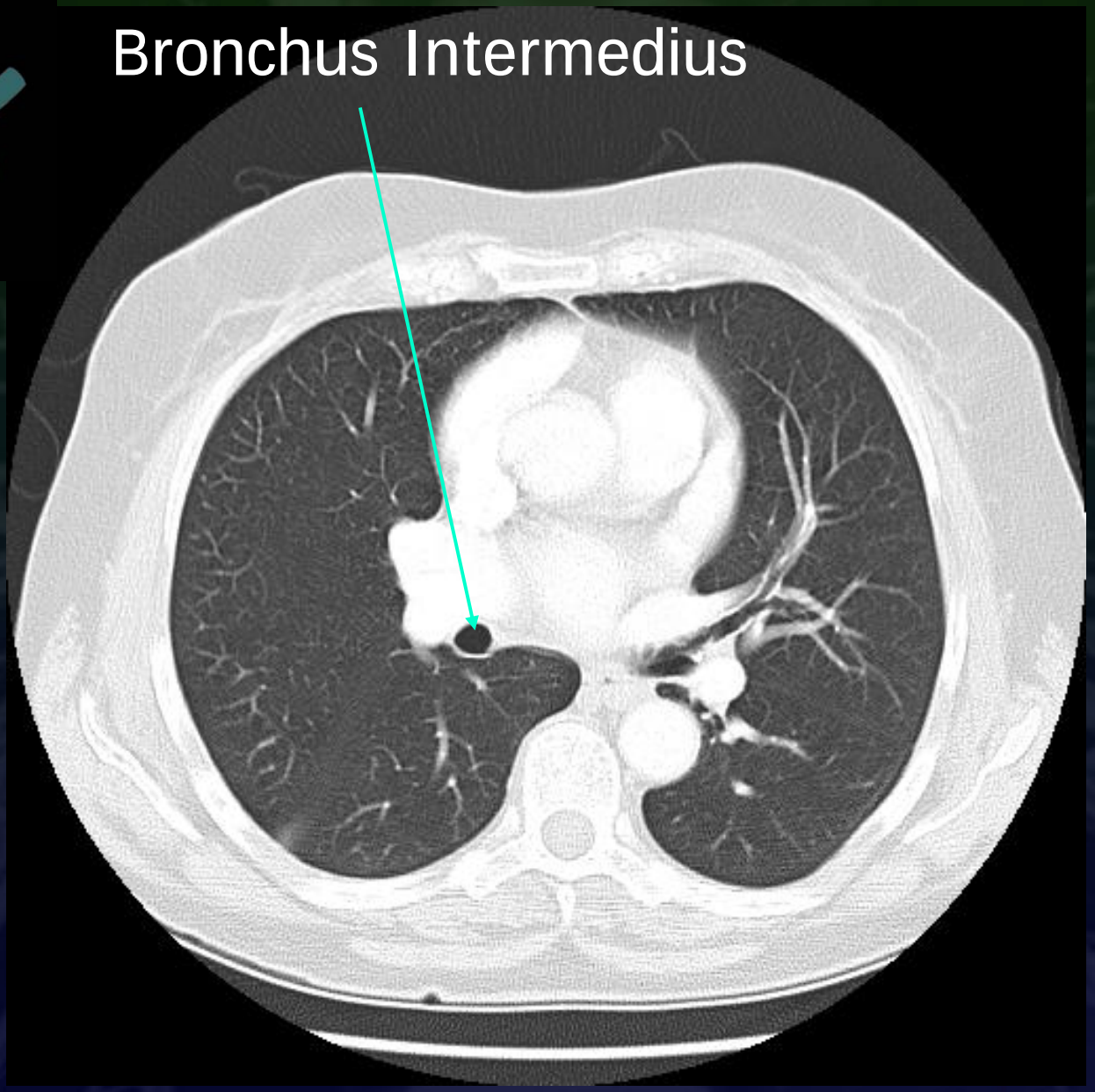


Oblique Fissures

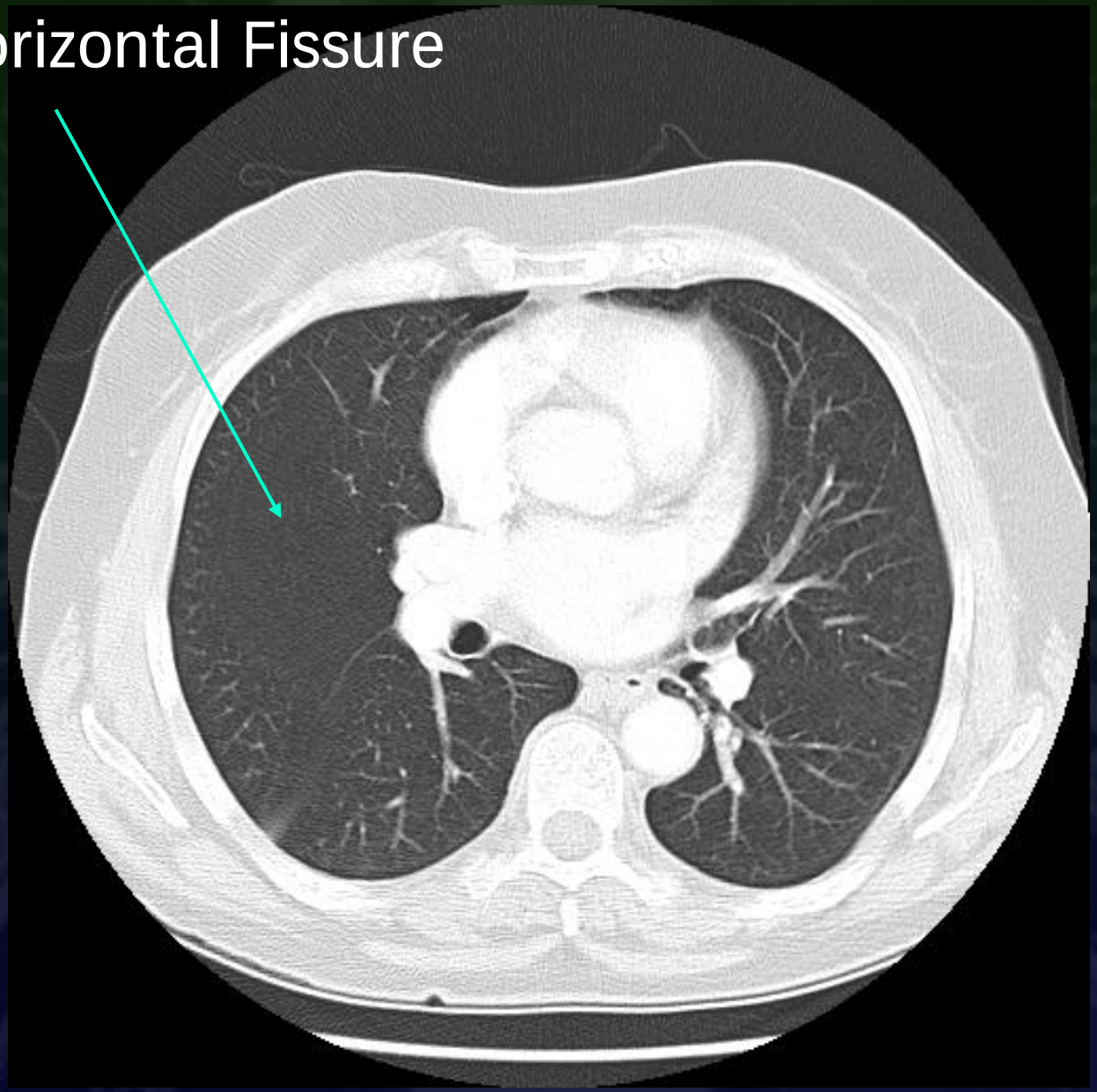


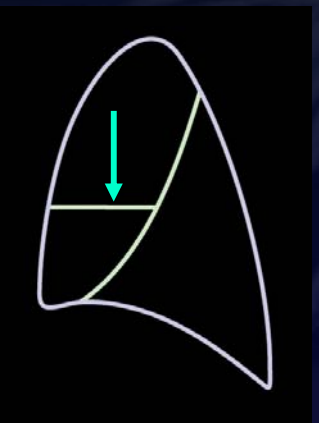

Left Main Stem Bronchus

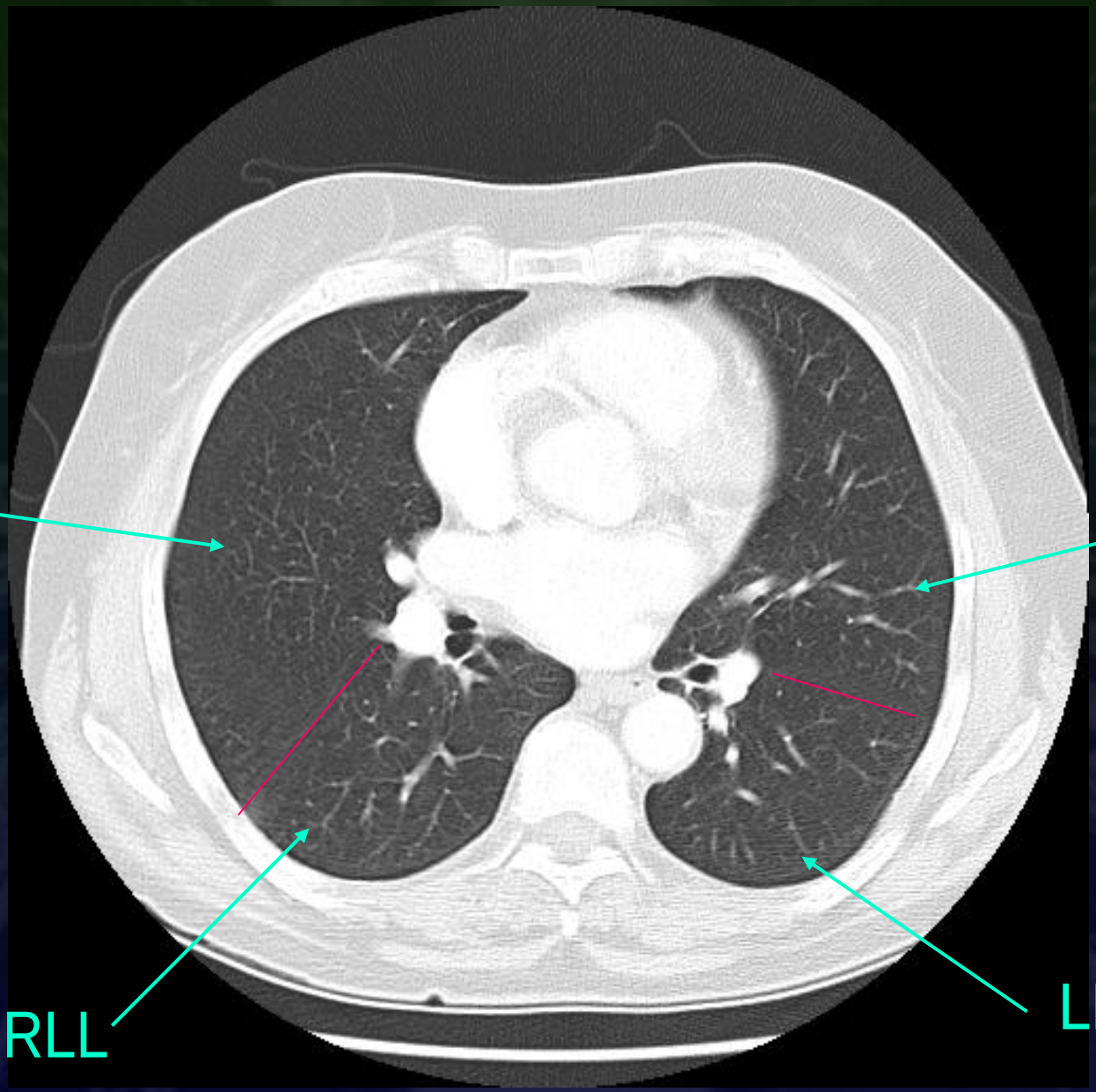
Bronchus Intermedius

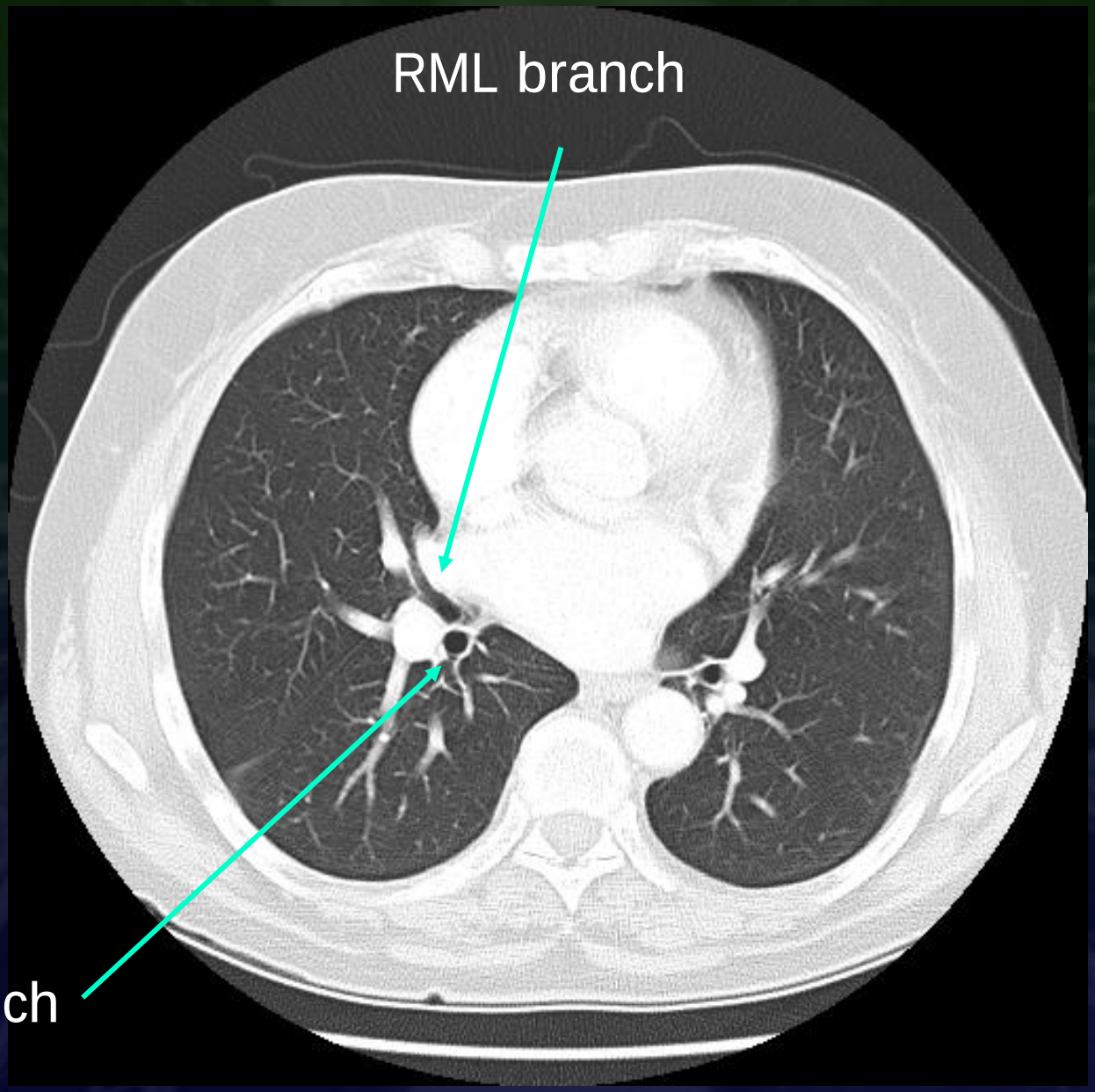


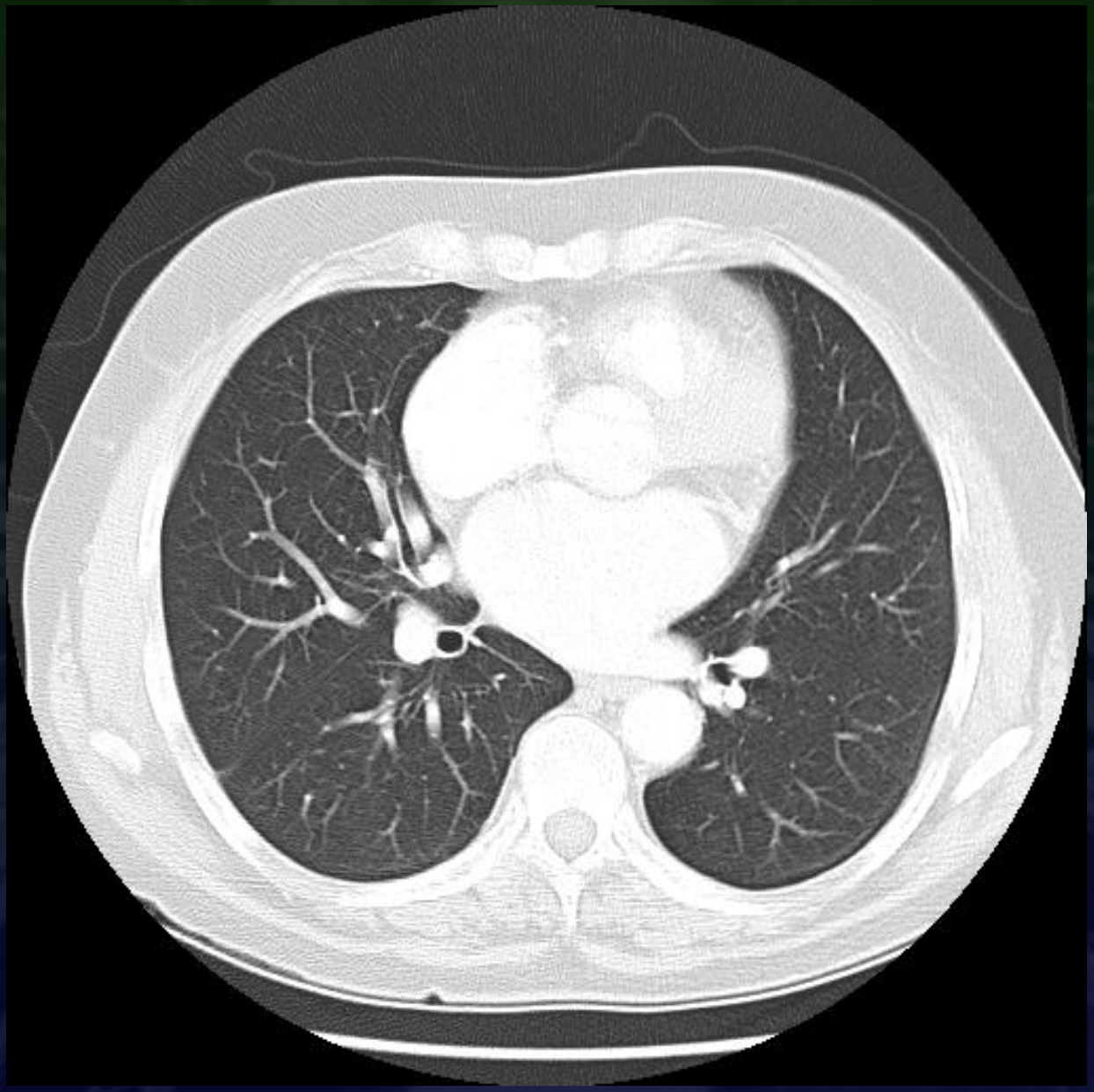
Horizontal Fissure

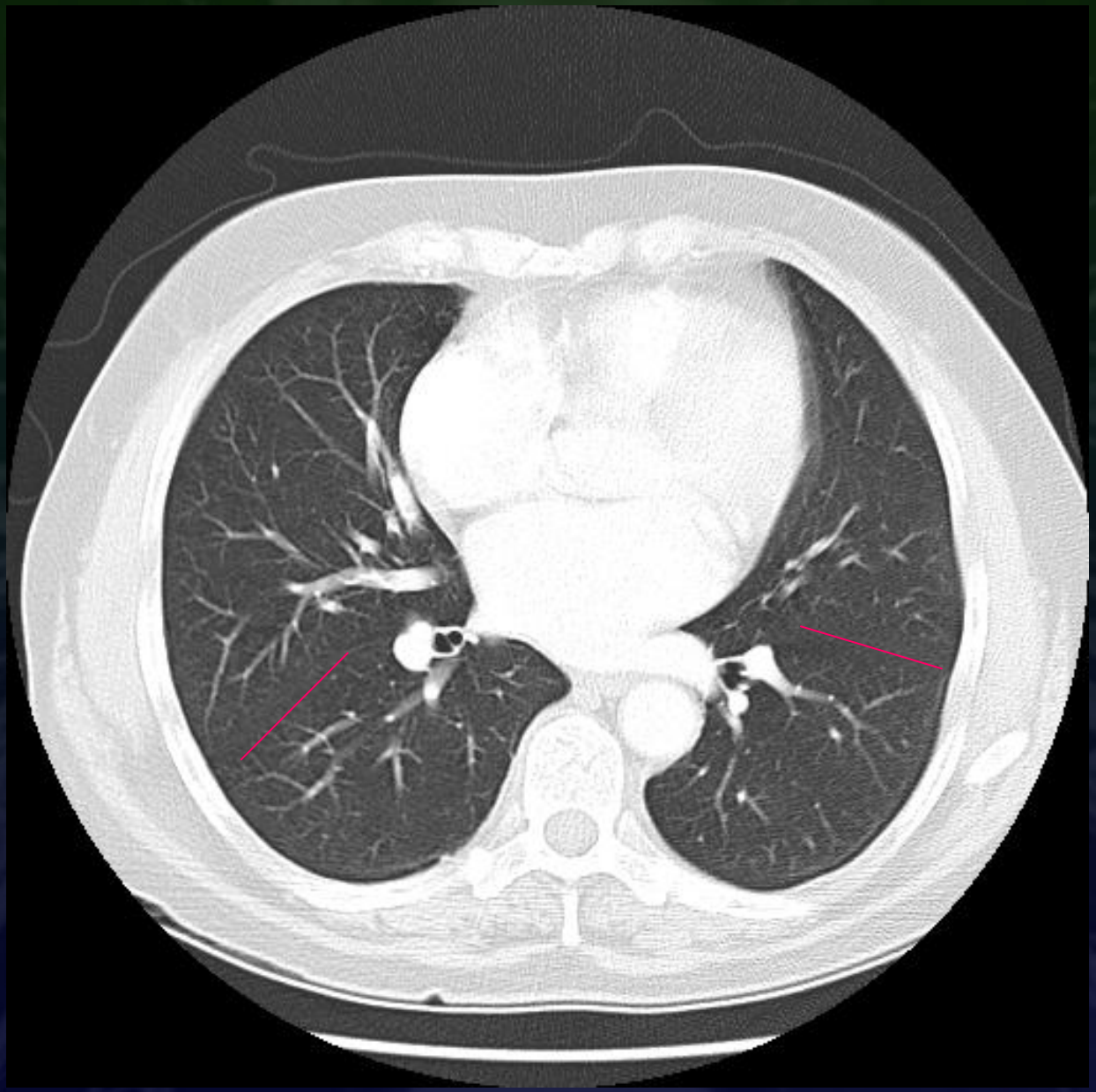


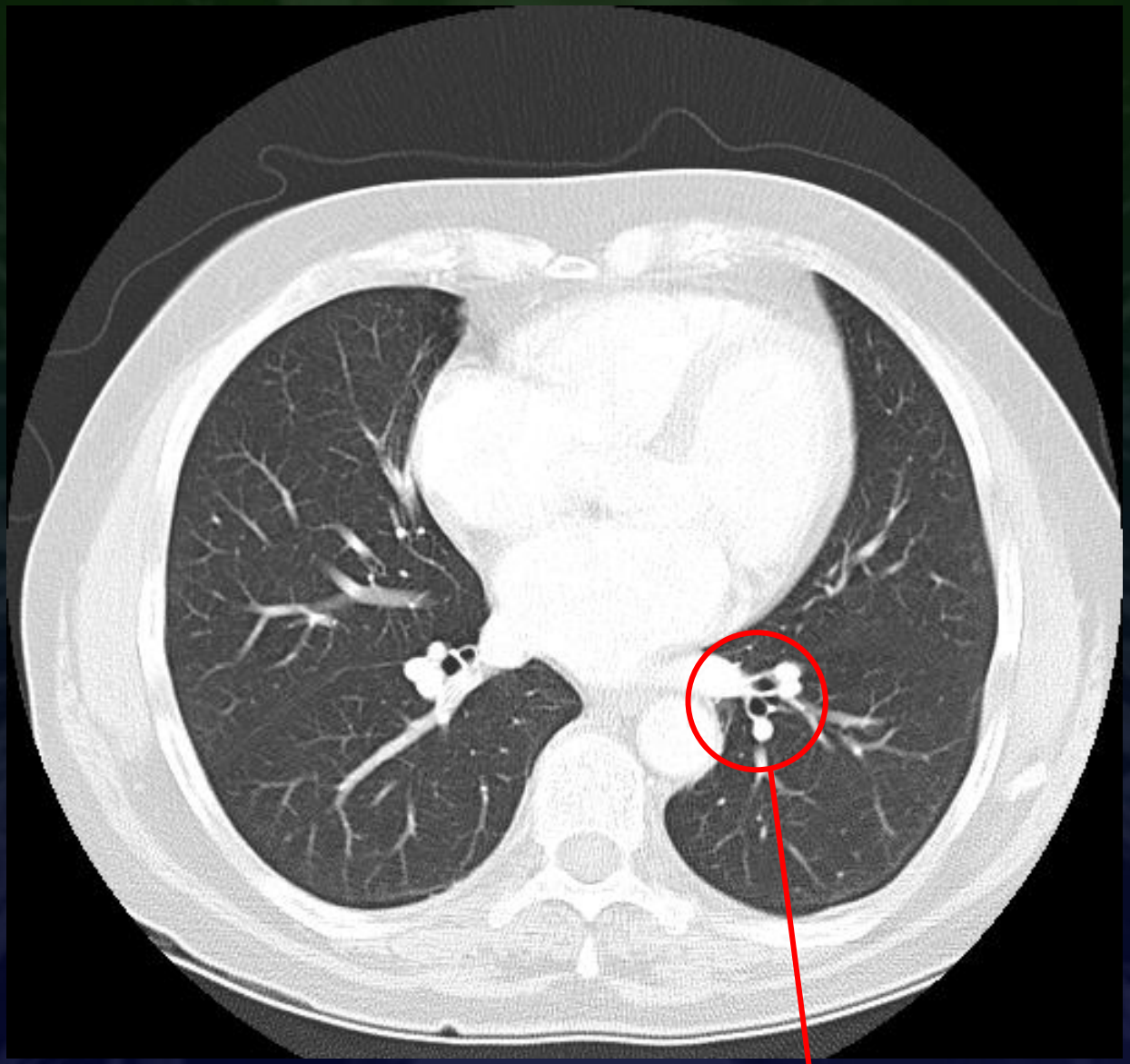


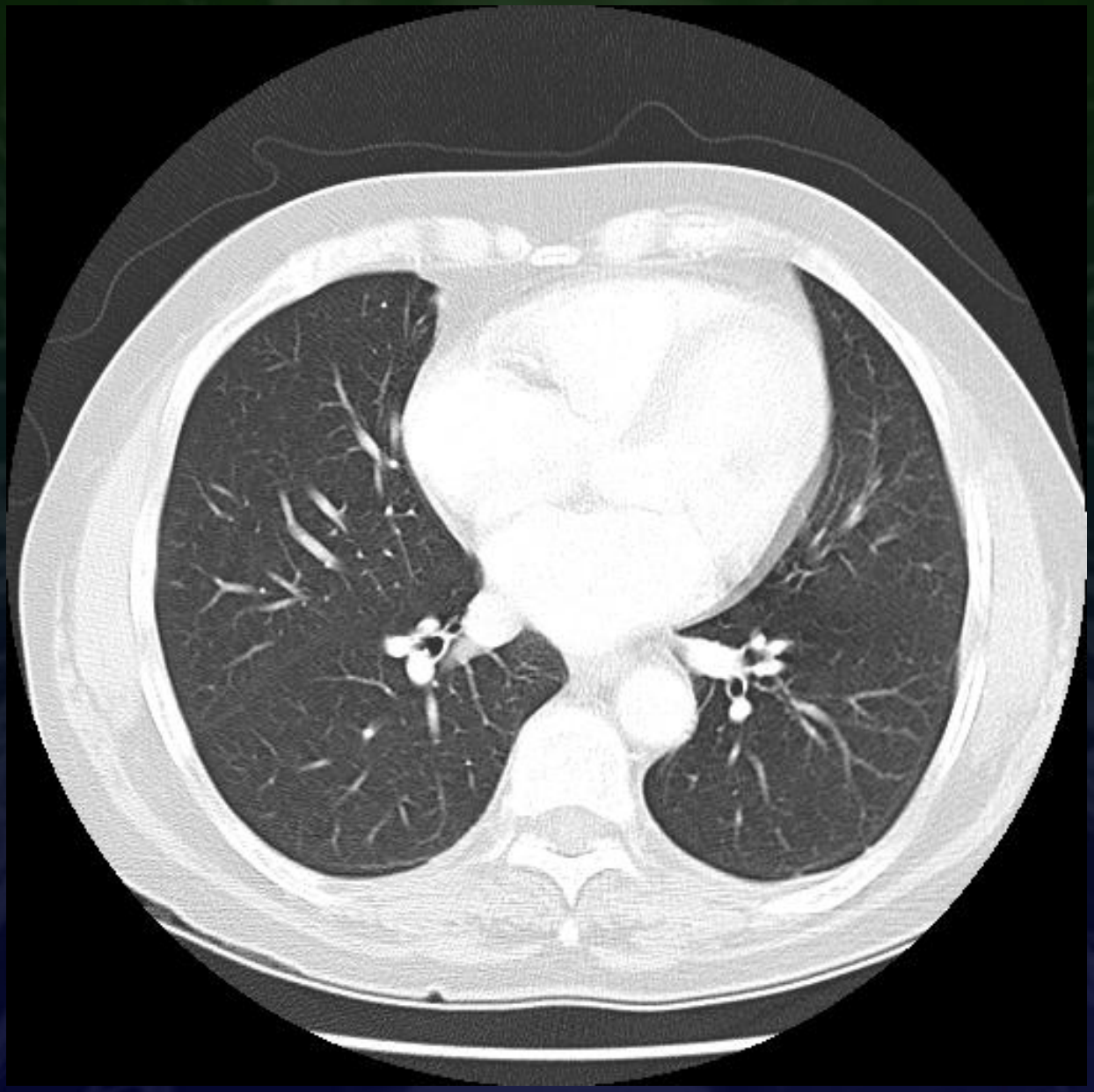

RML
LUL
RLL
LLL

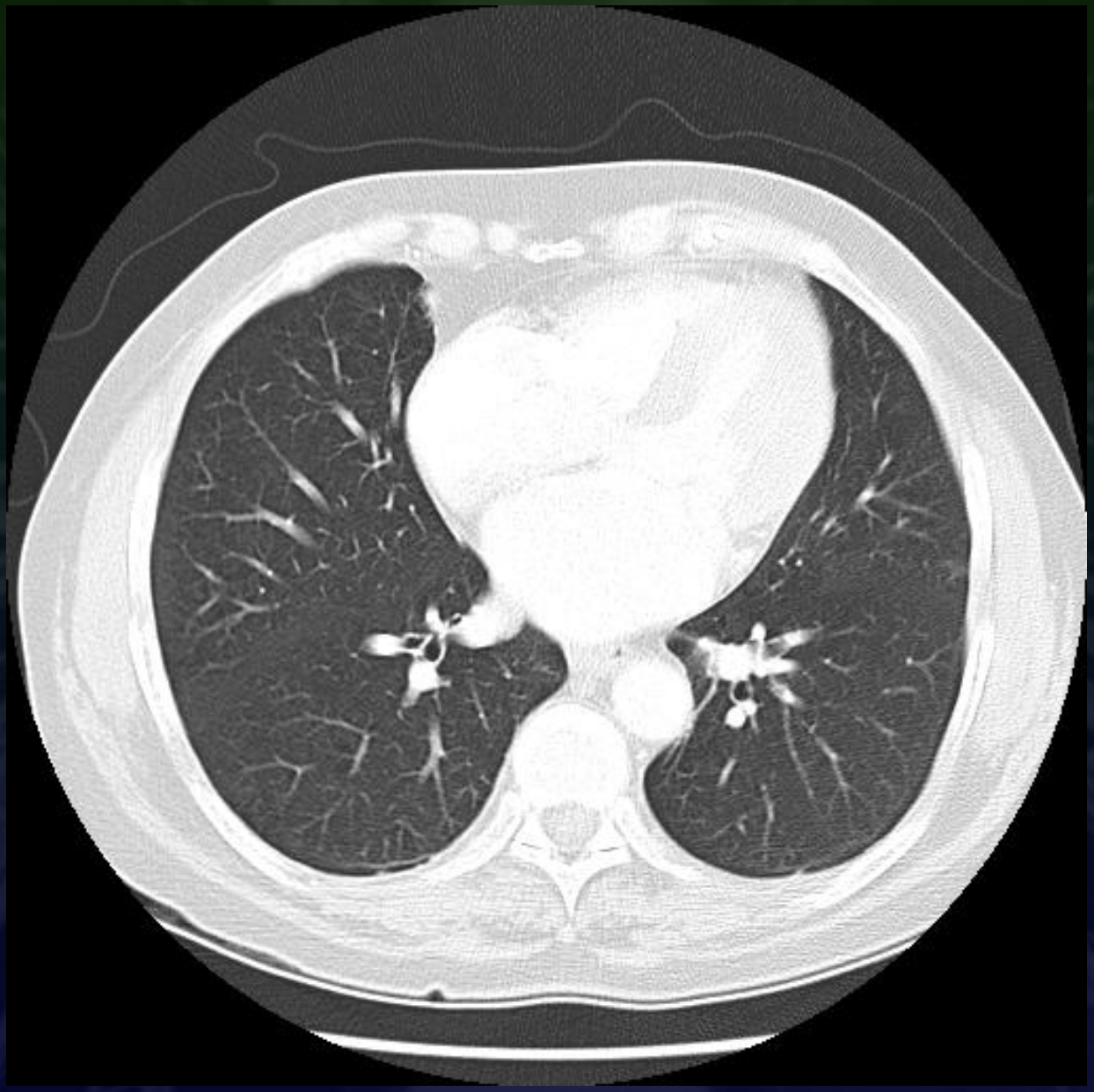

RML branch
RLL branch



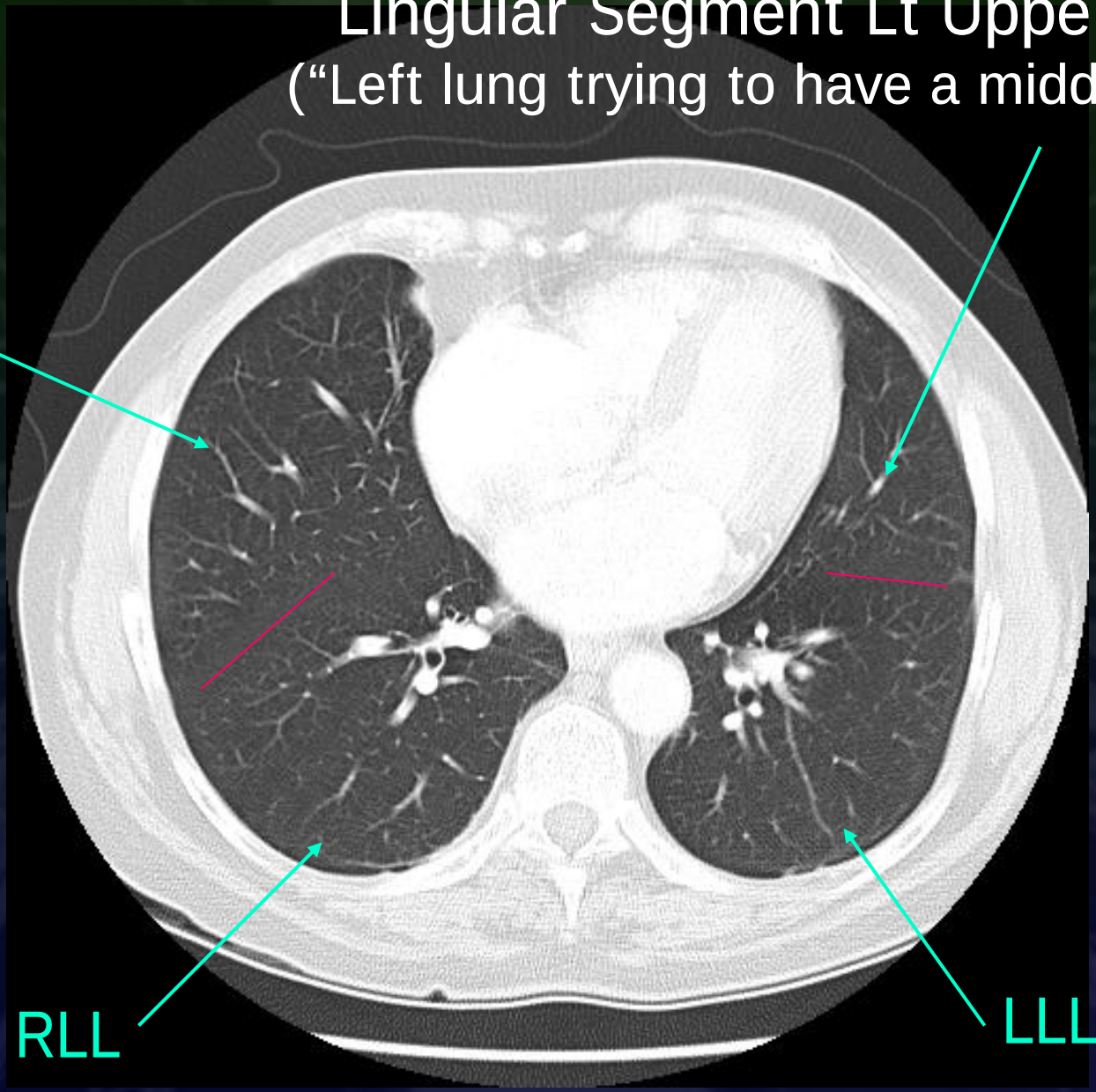


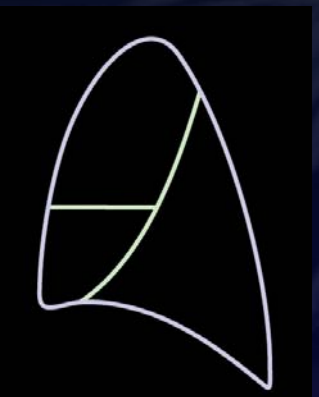

Segmental divisions

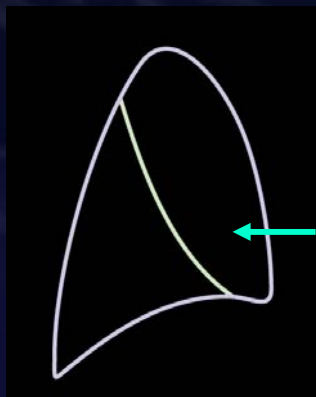


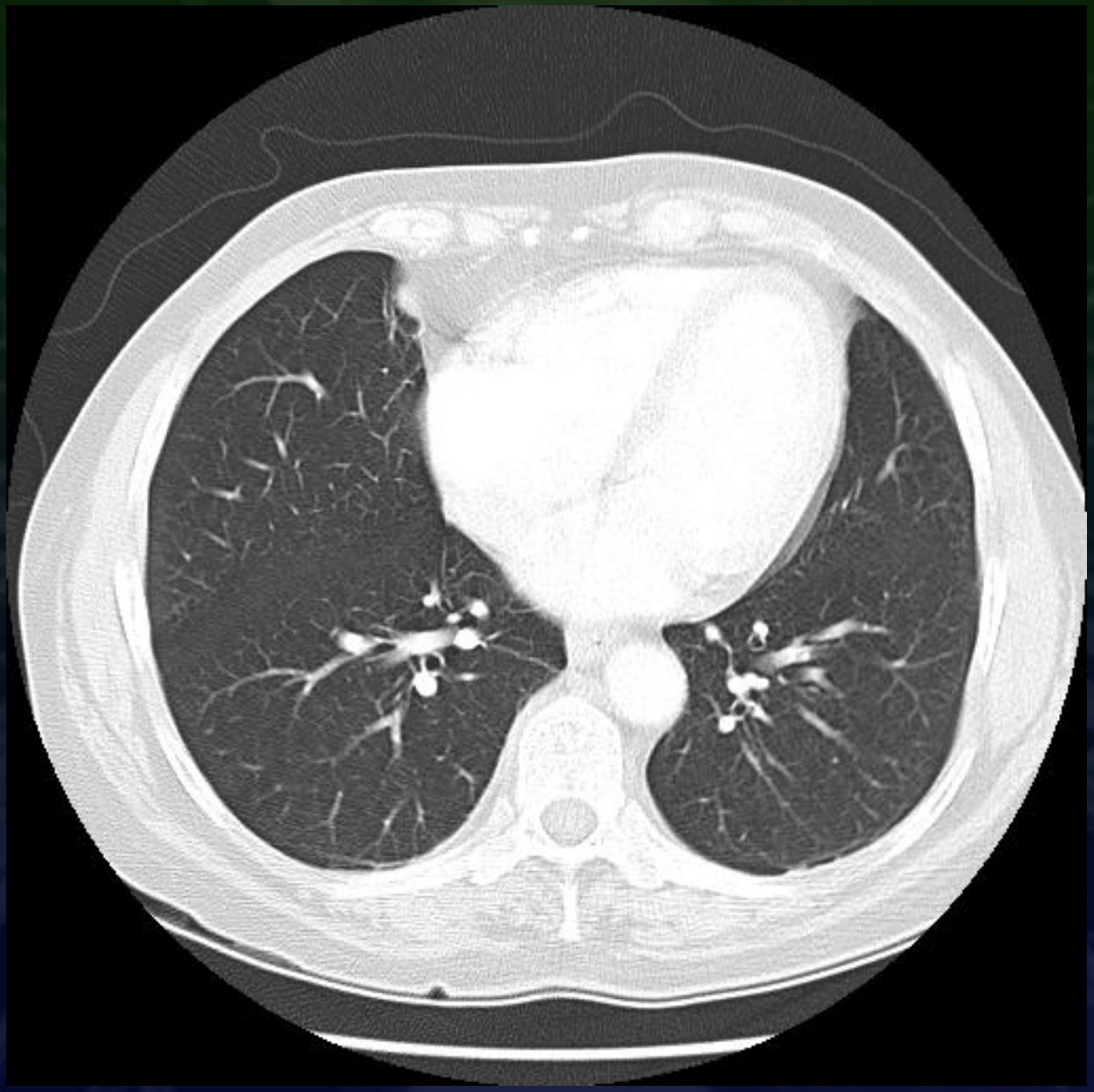


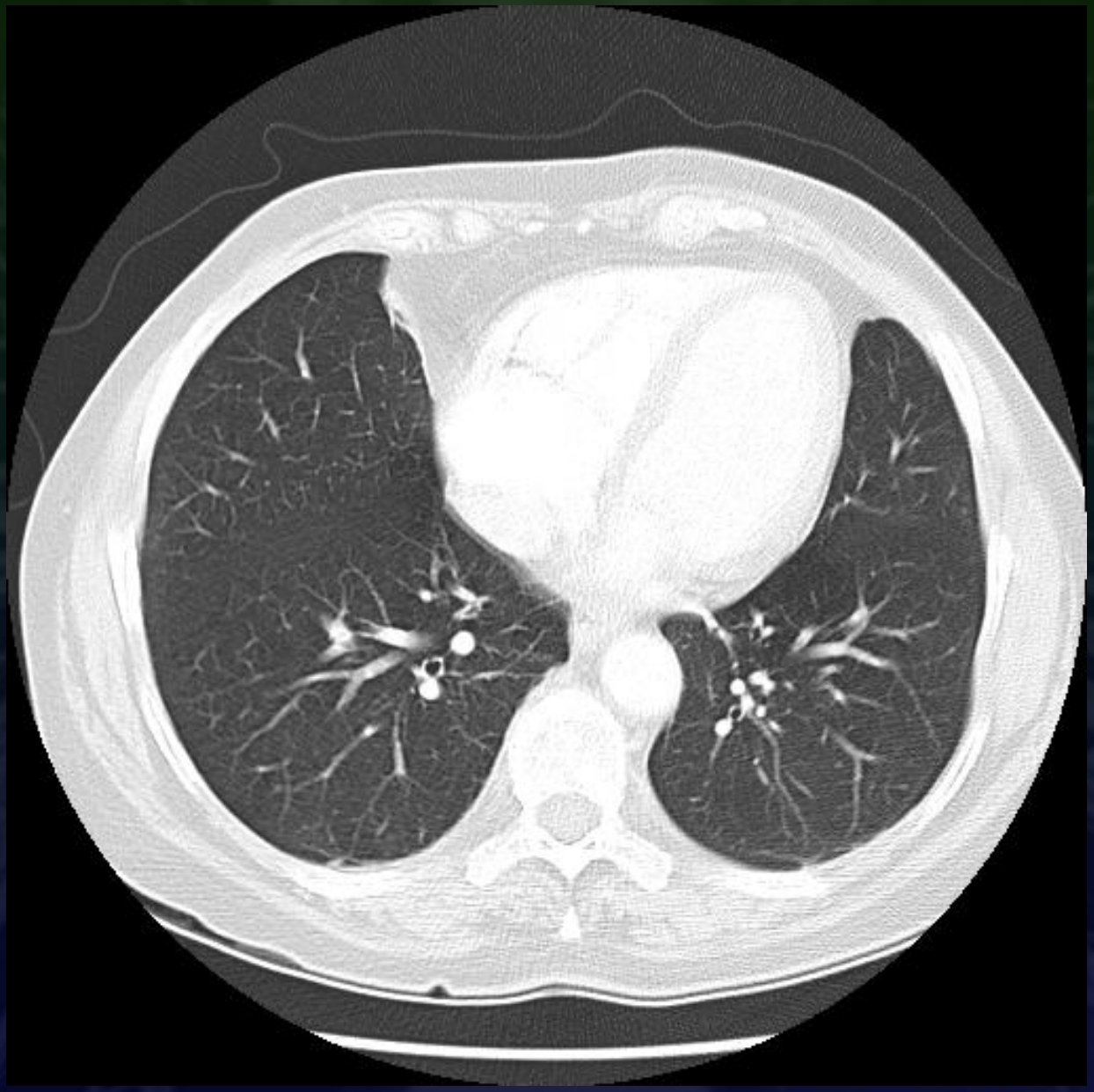
Lingular Segment Lt Upper Lobe
("Left lung trying to have a middle lobe!")

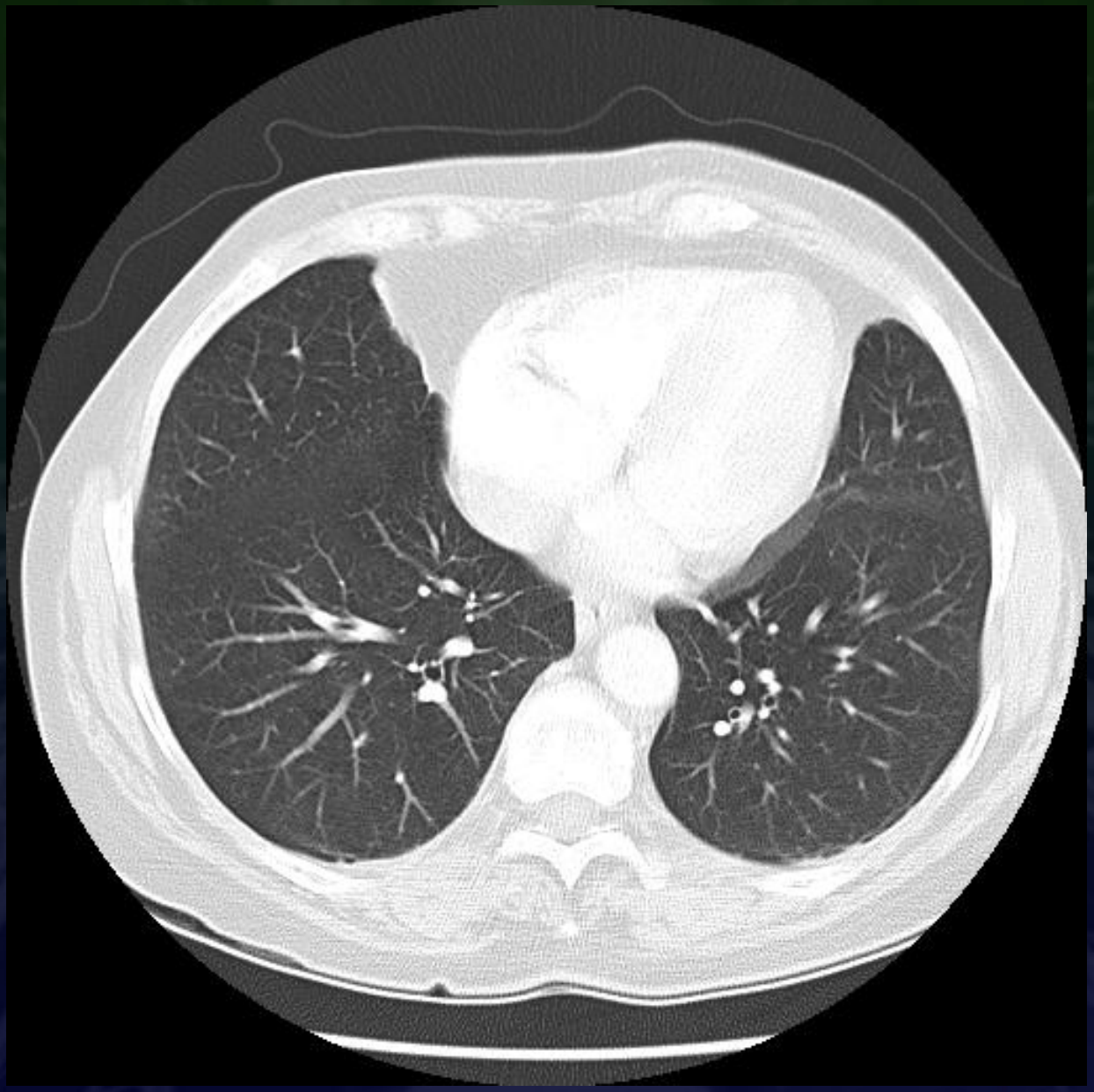


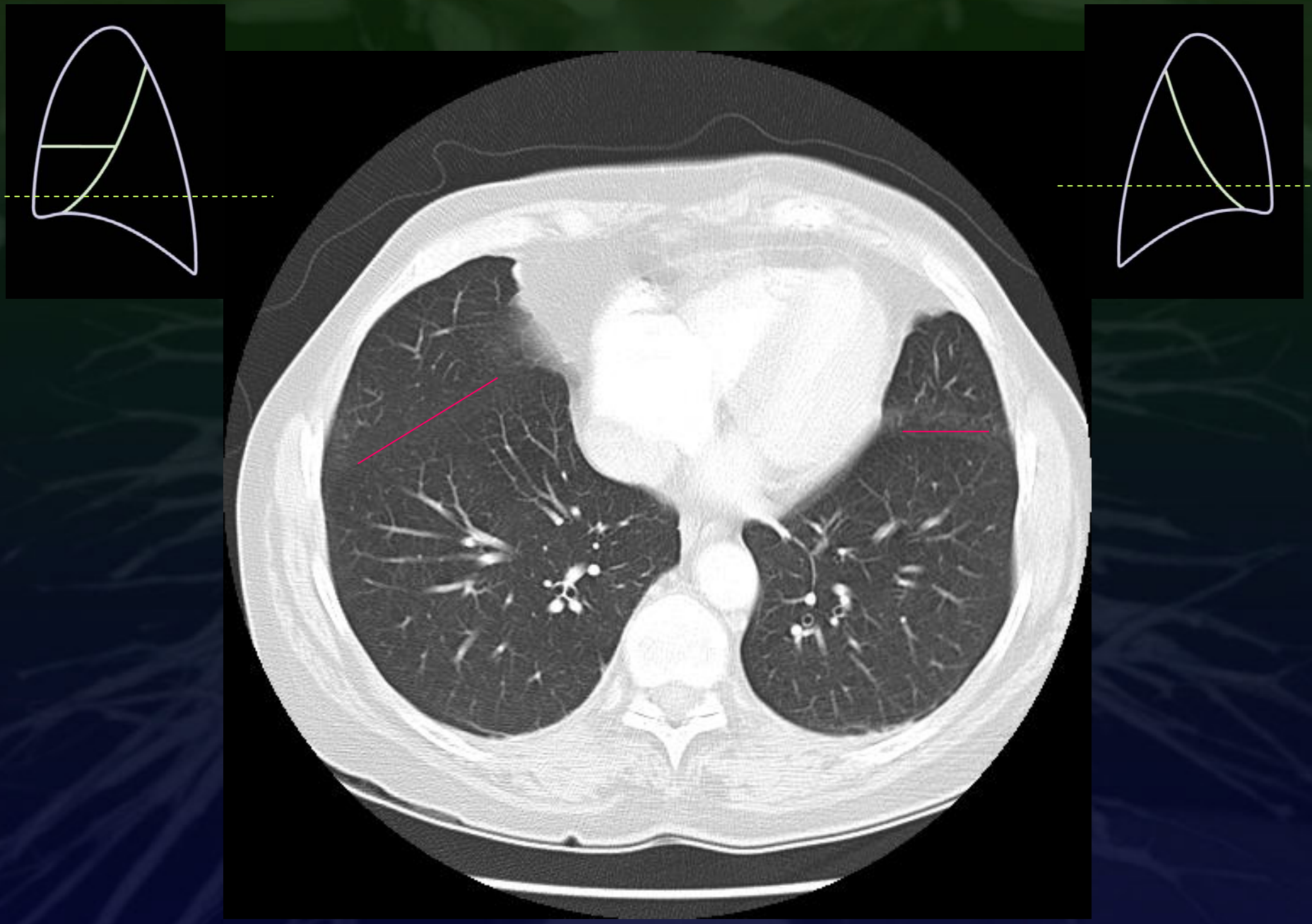


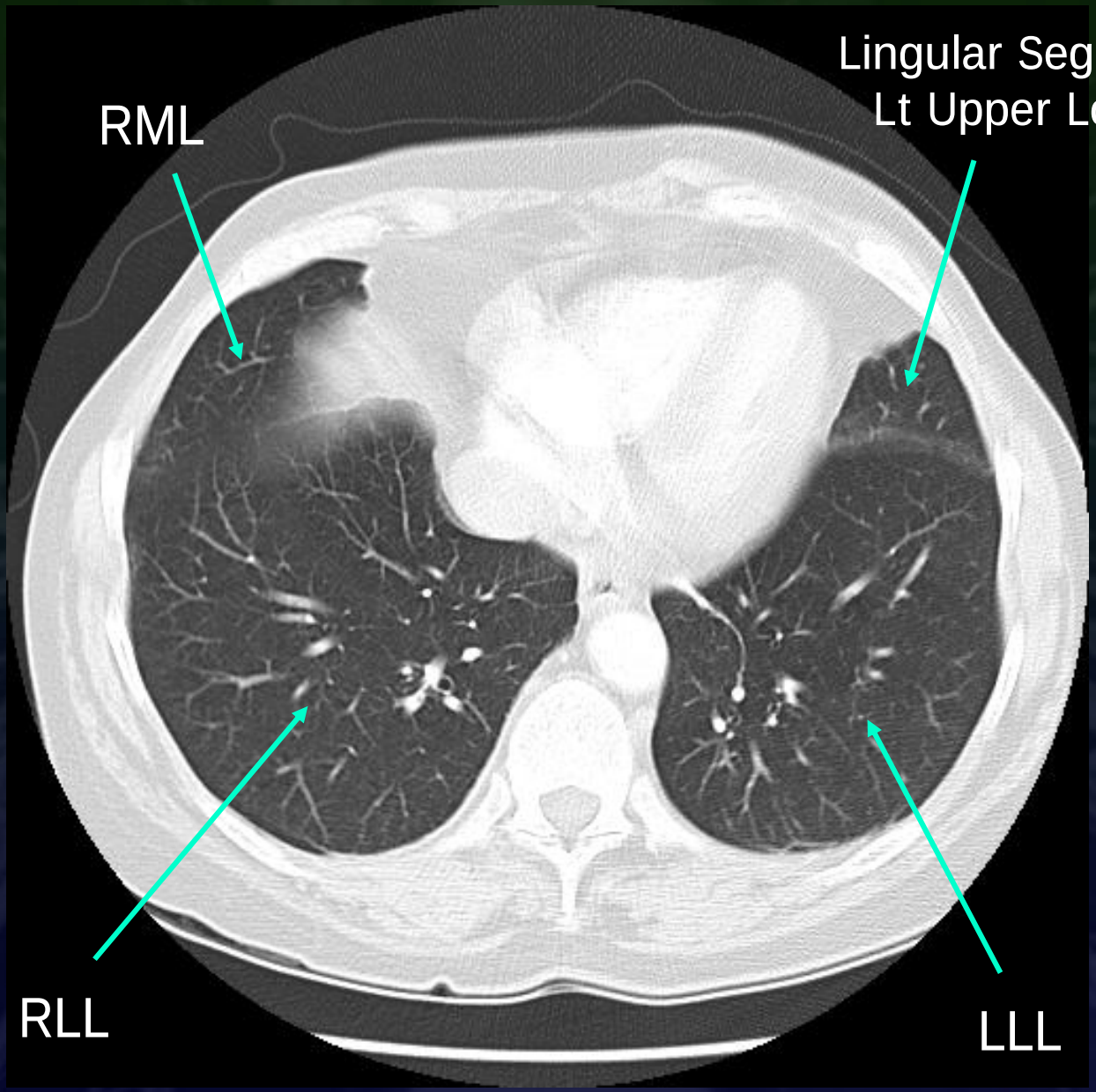


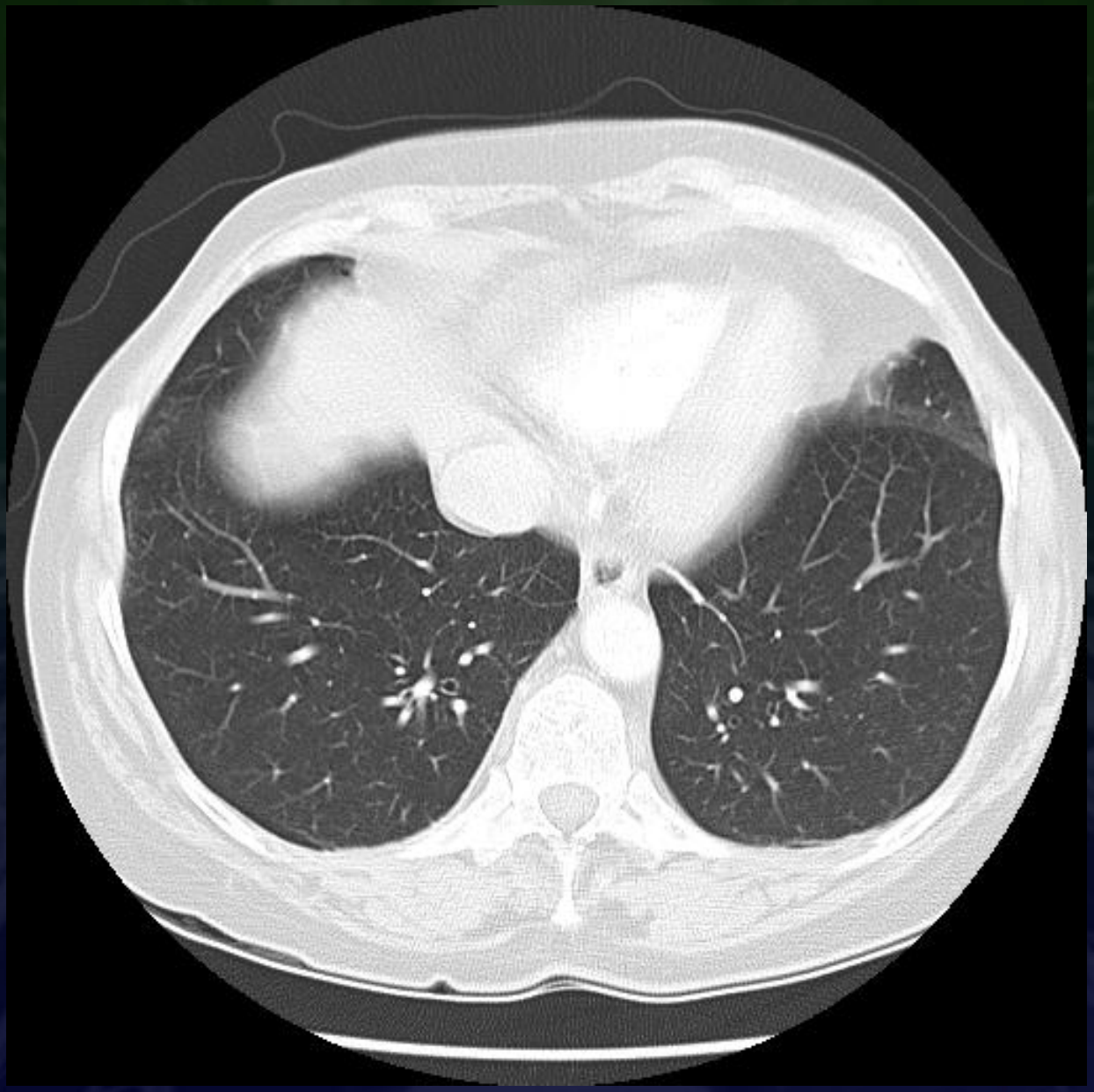


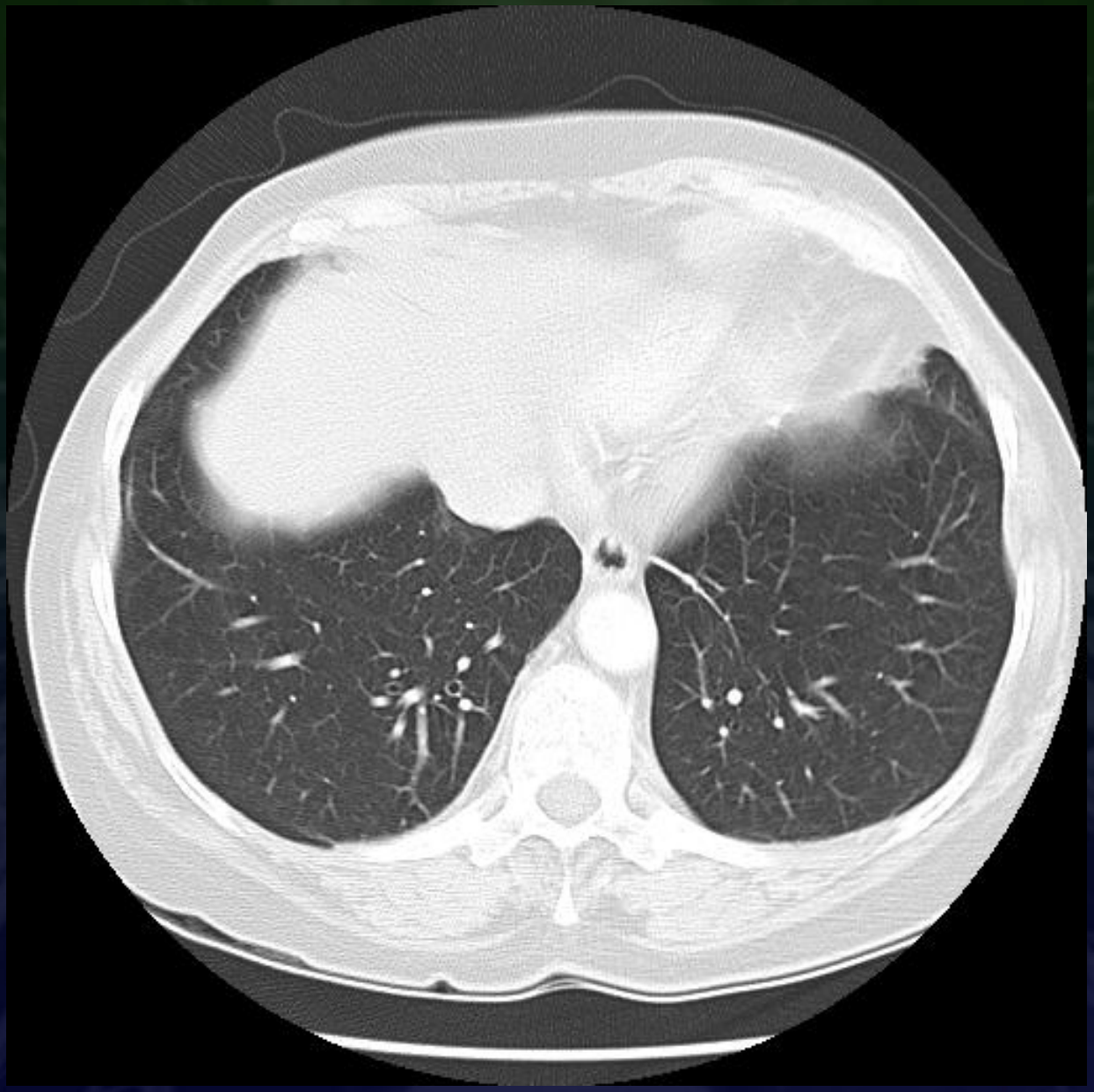


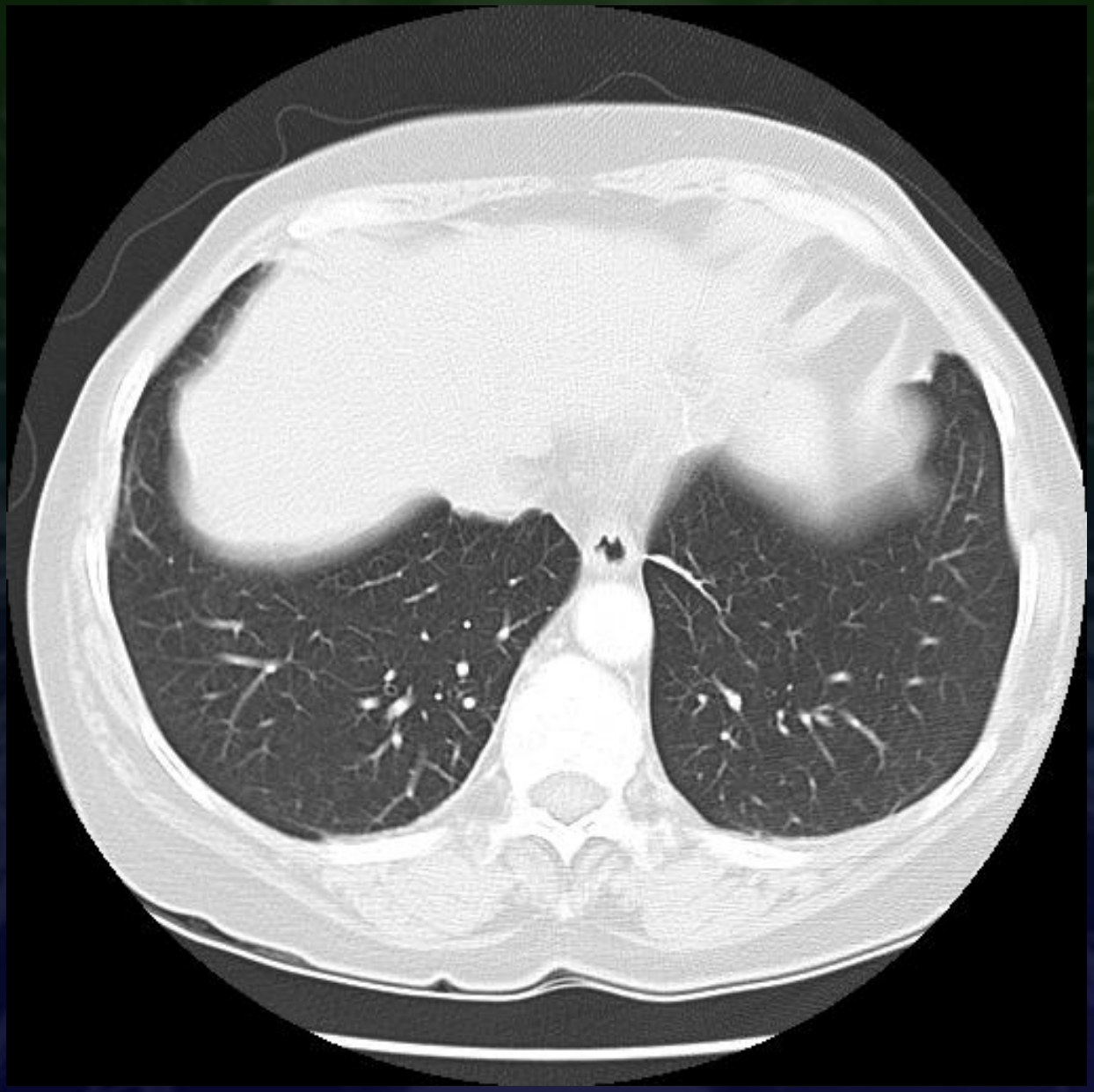


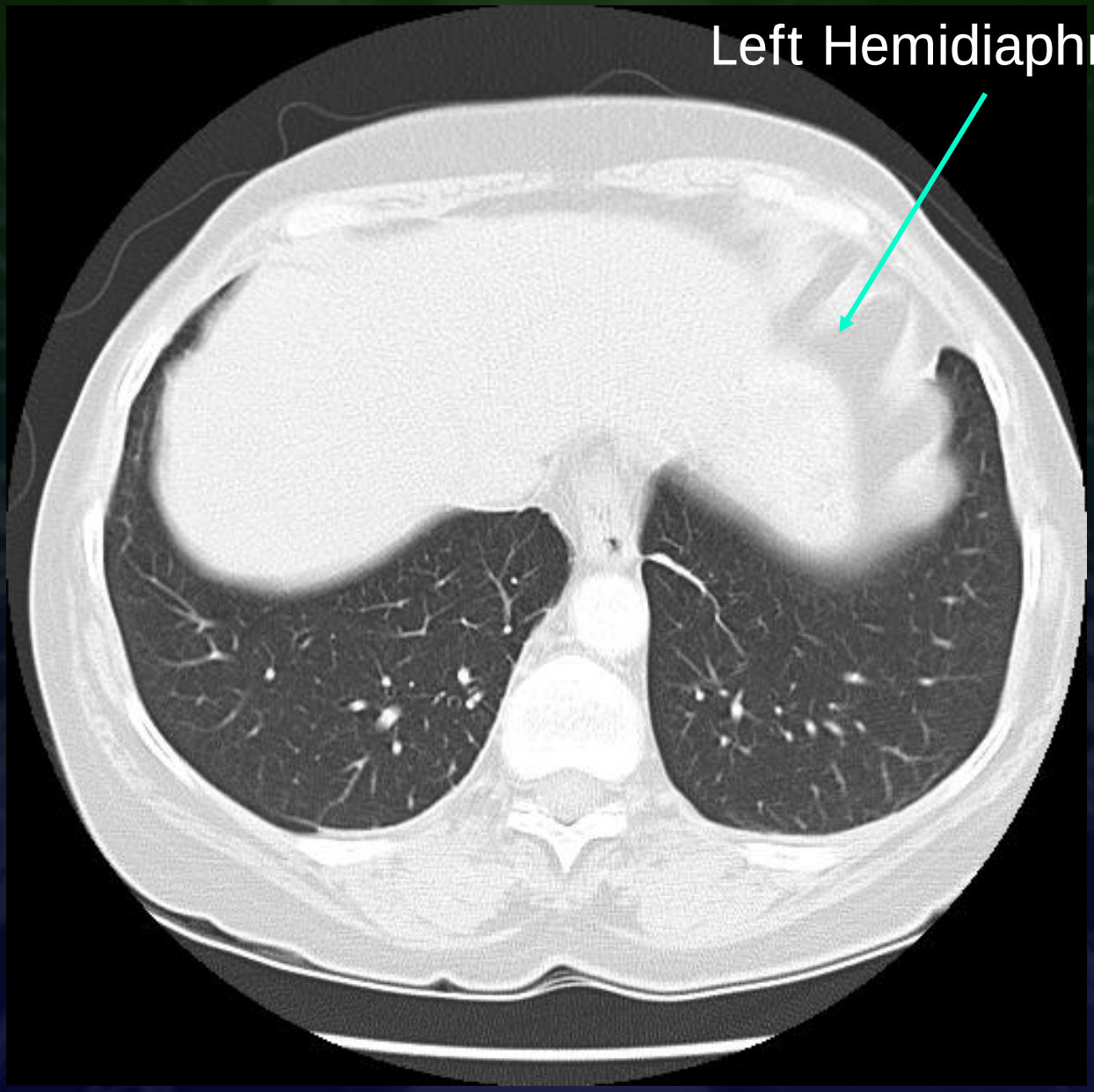


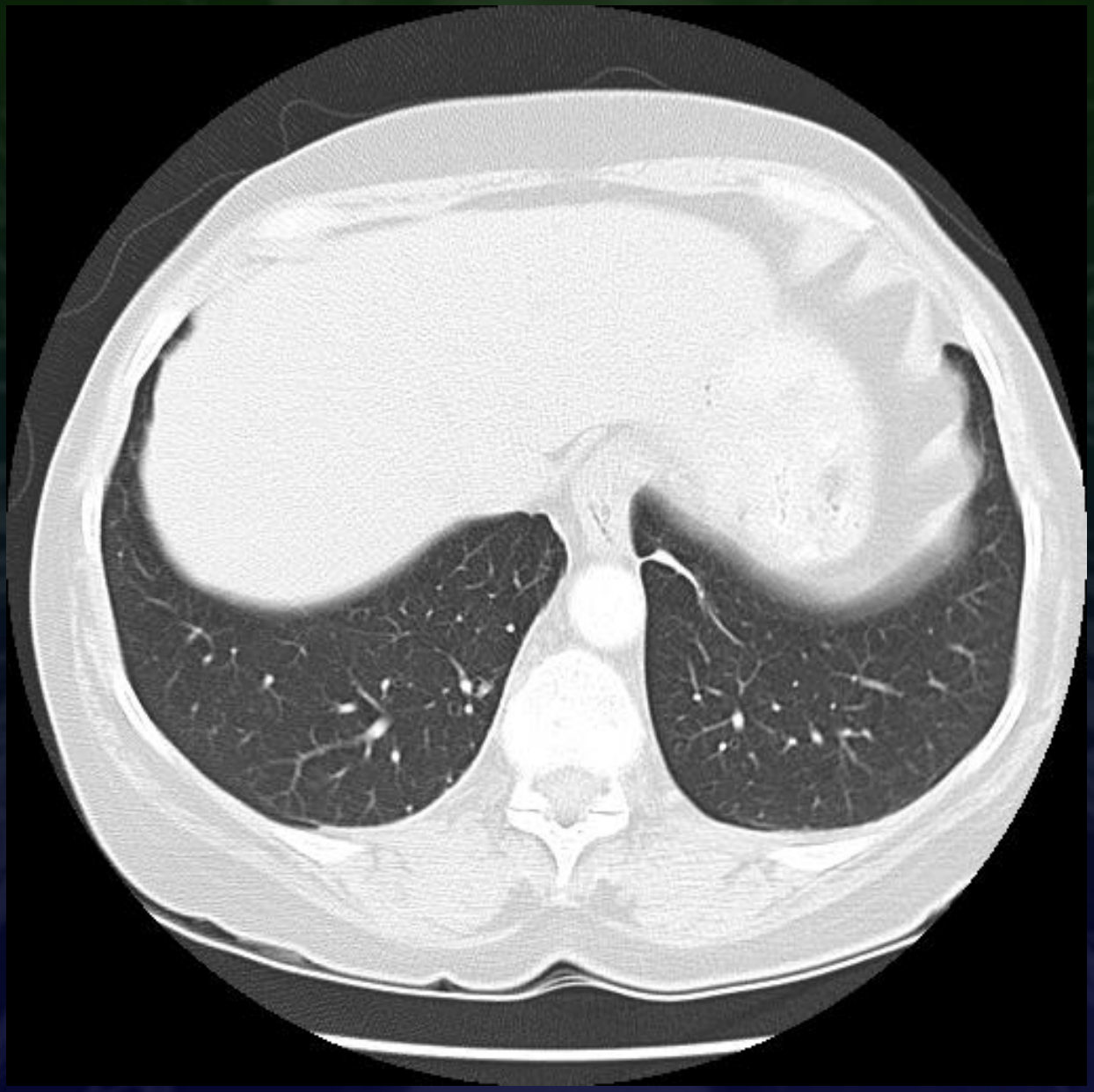

RML
Lingular Segment
Lt Upper Lobe
RLL
LLL

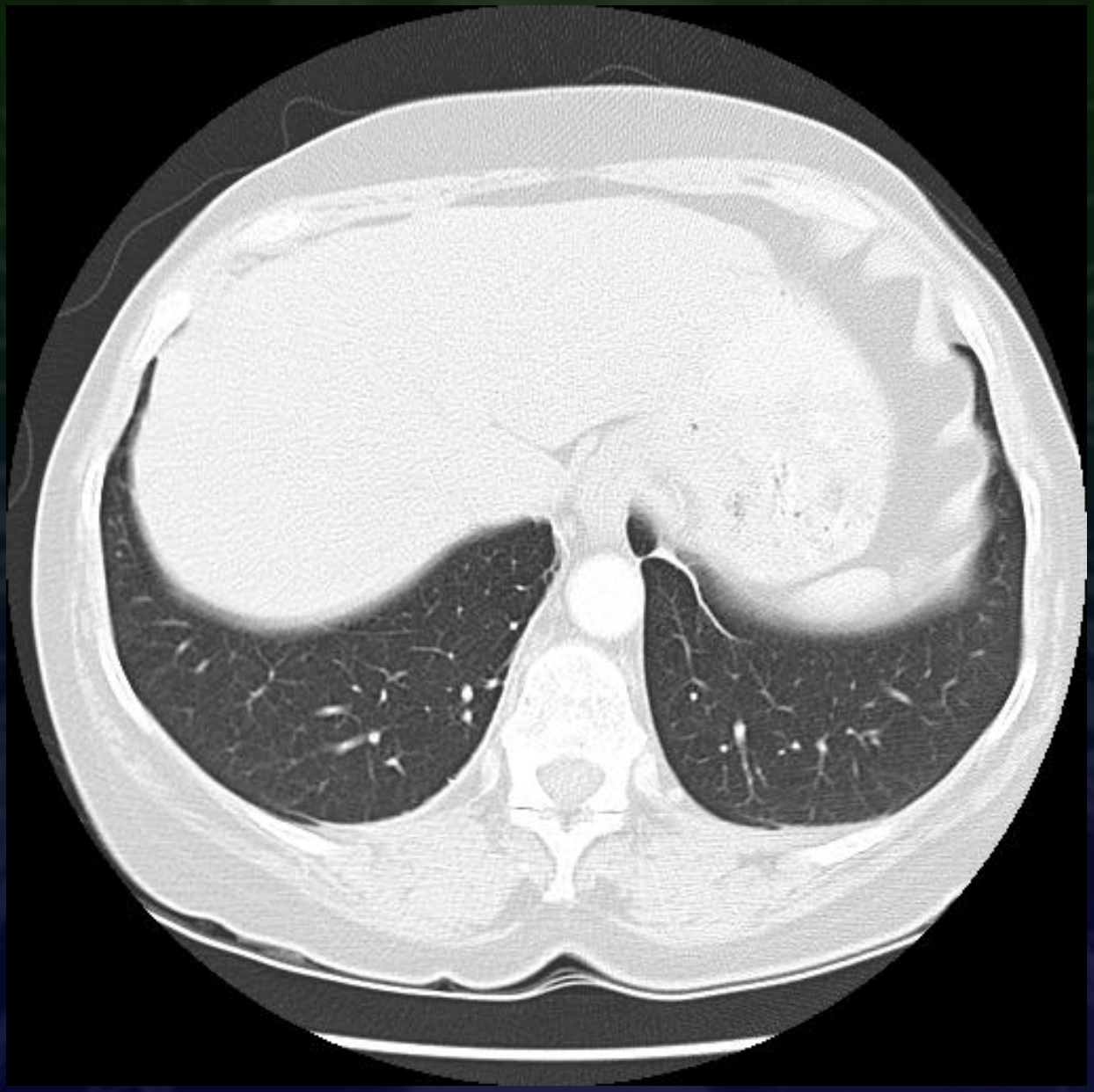


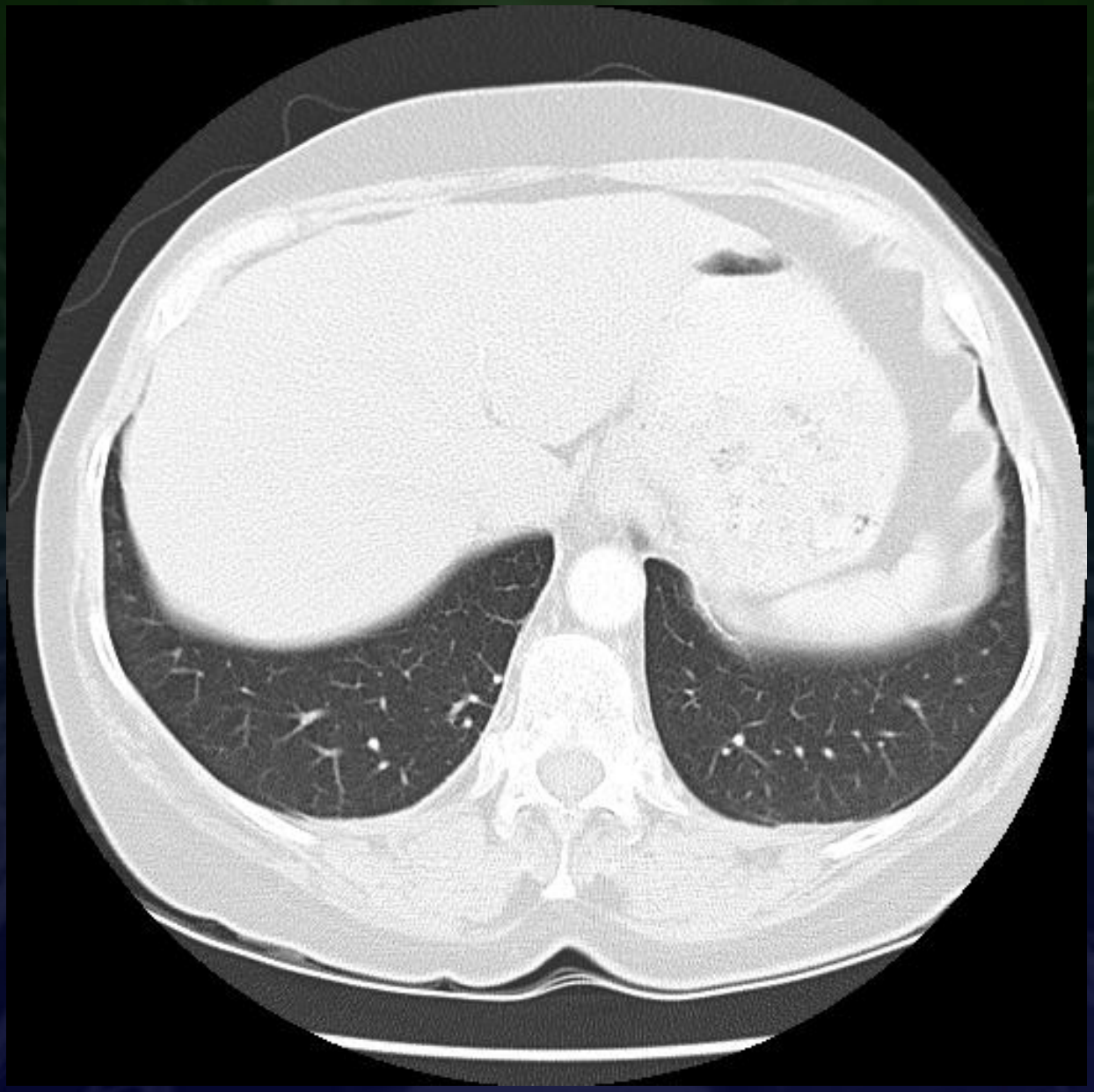


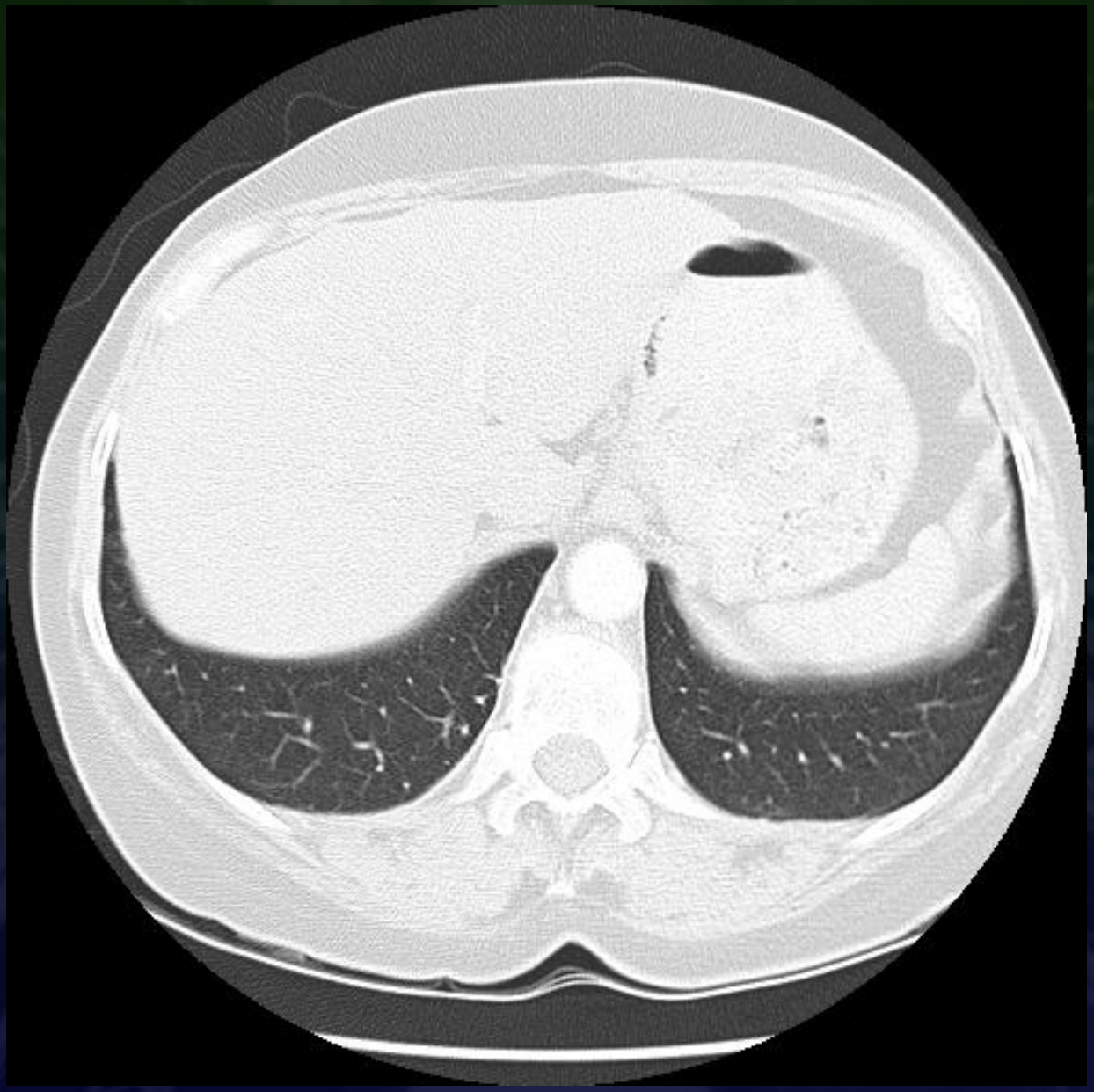


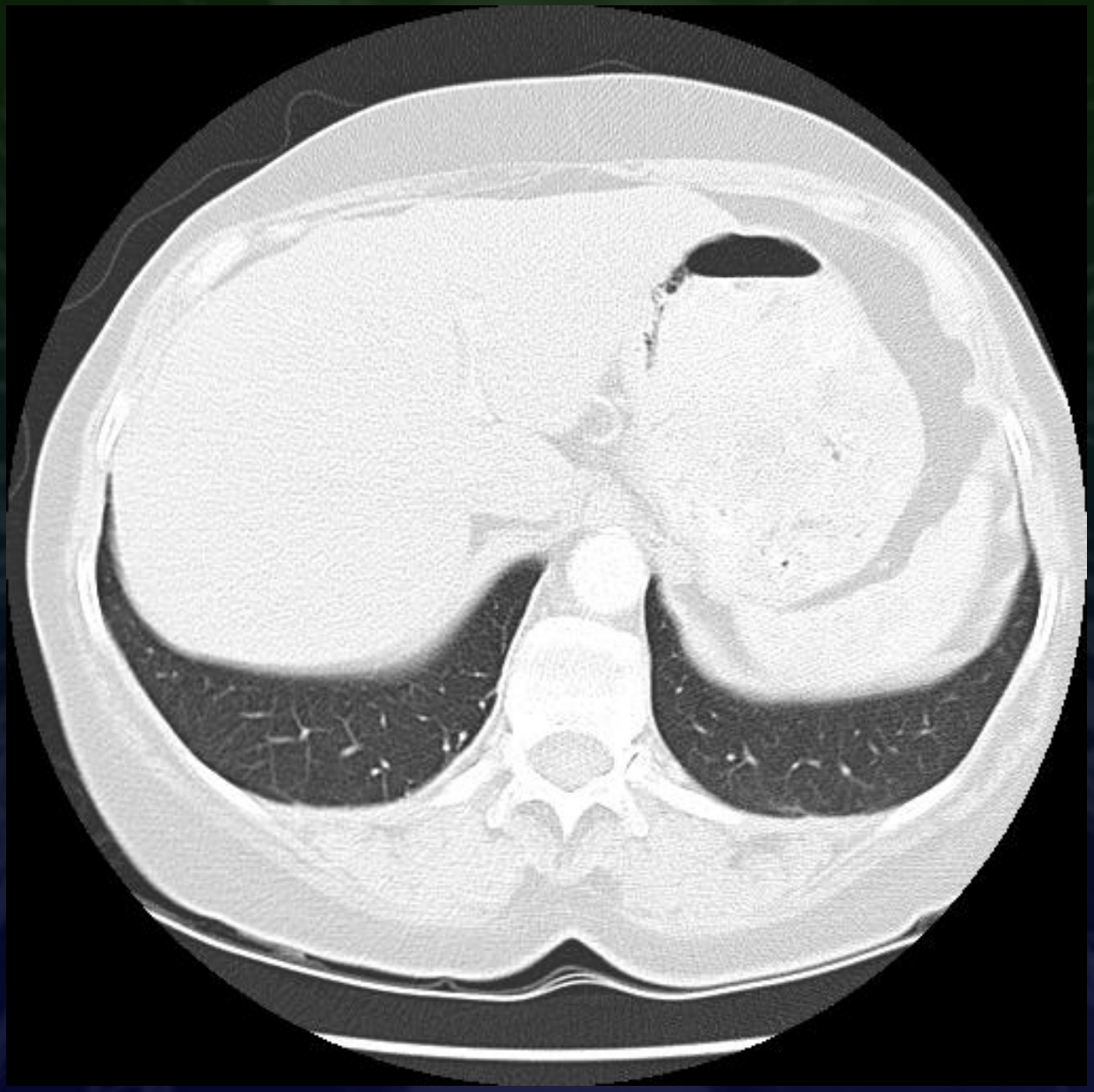

Left Hemidiaphragm

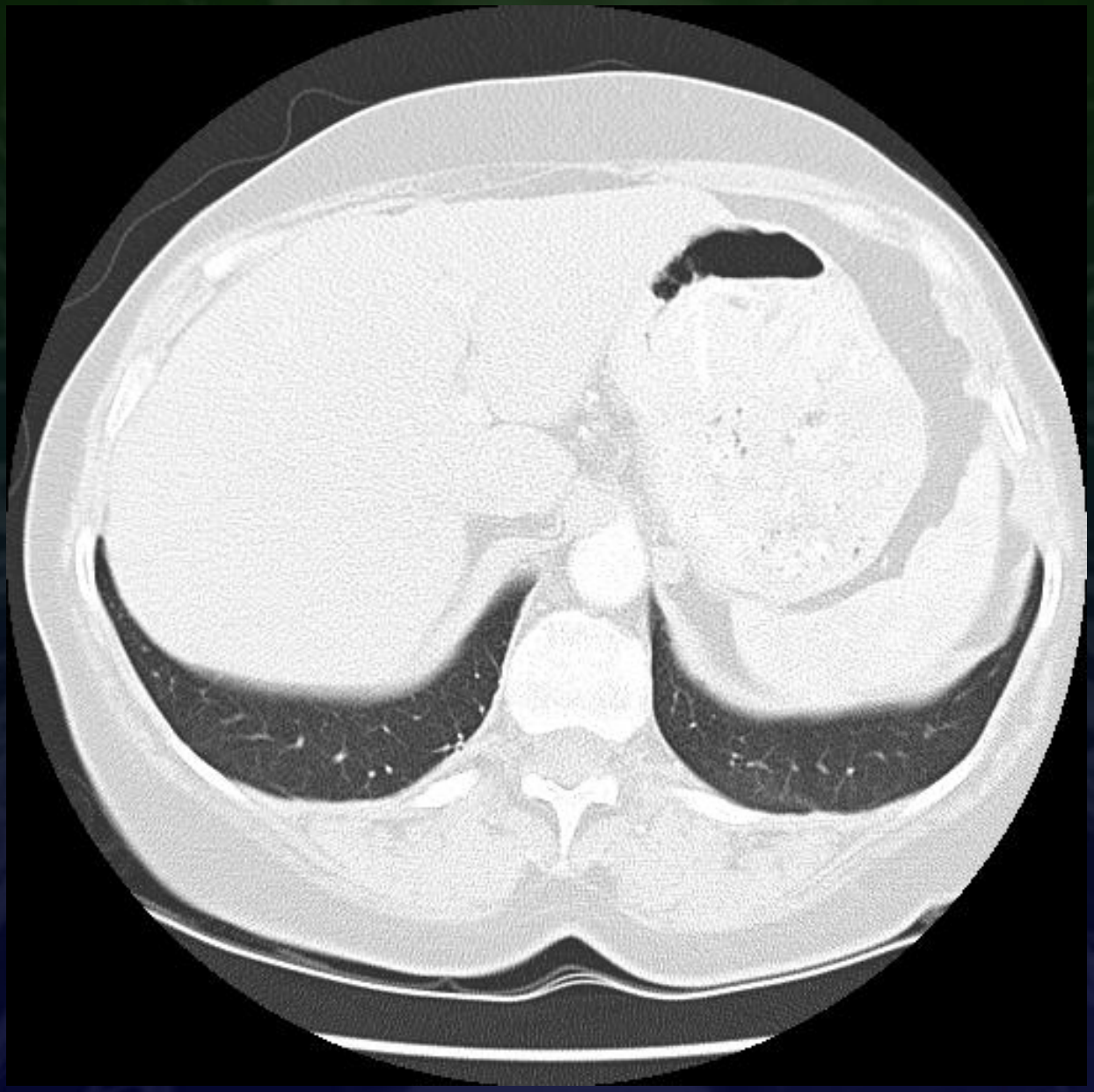


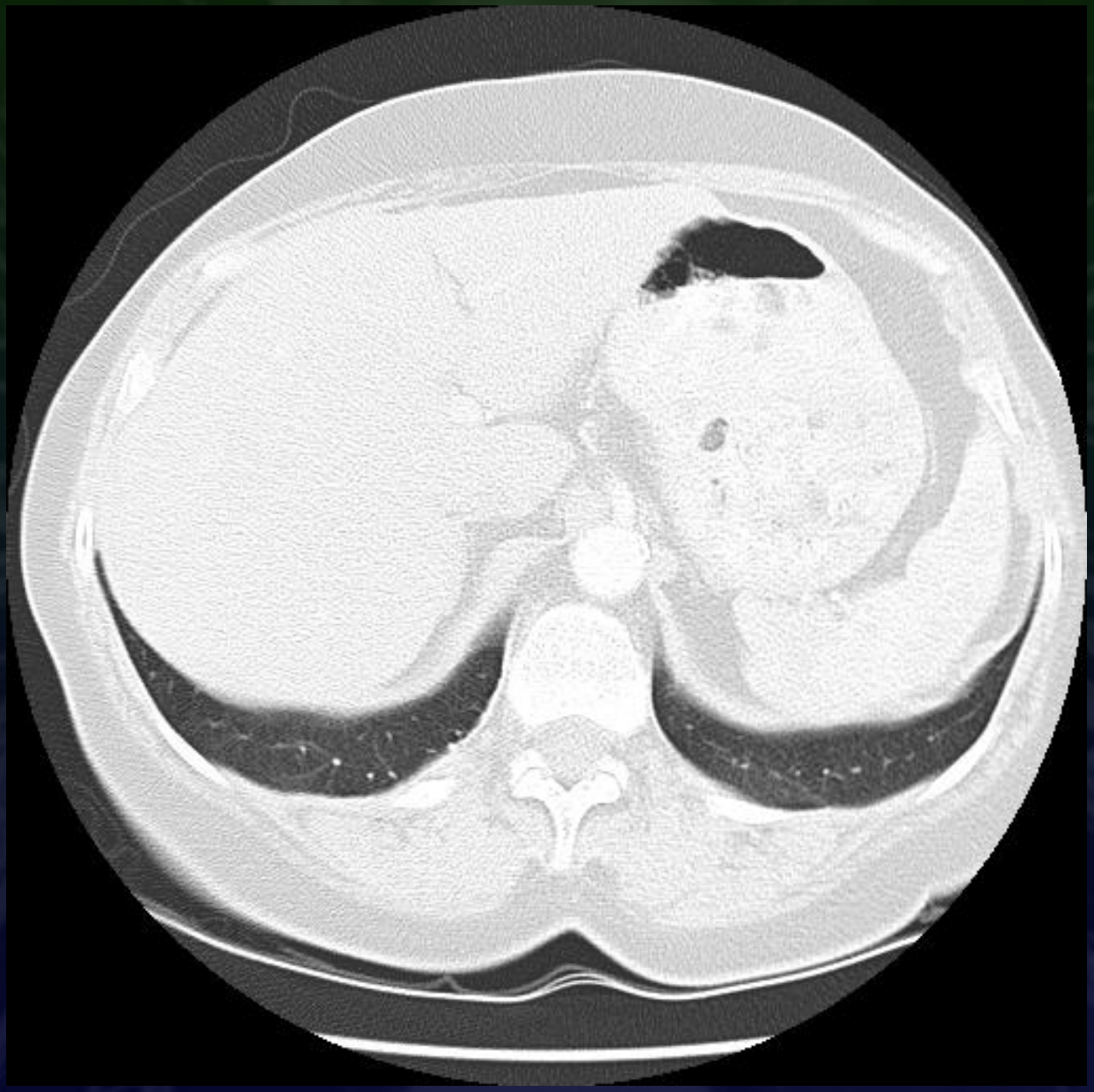


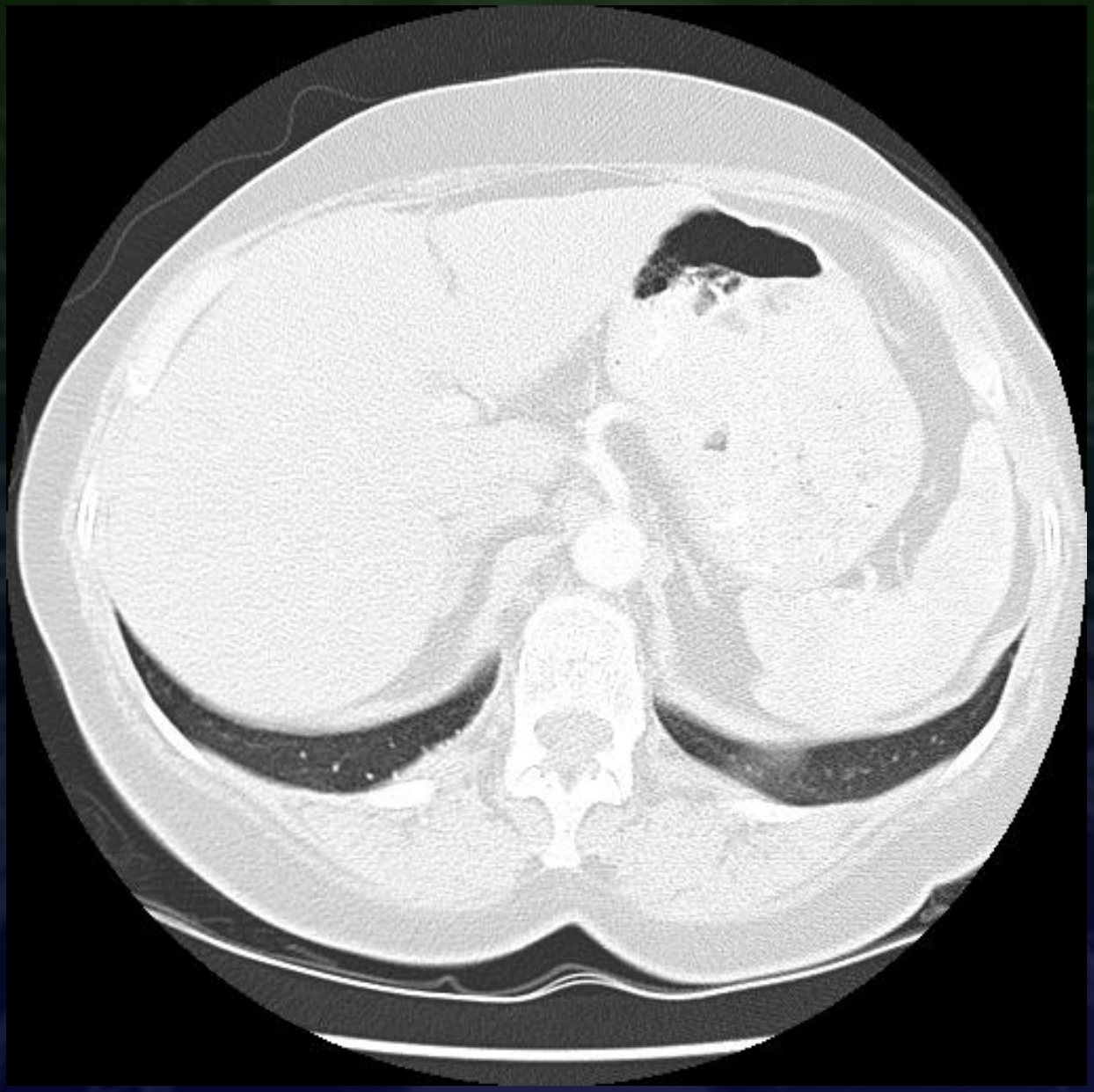




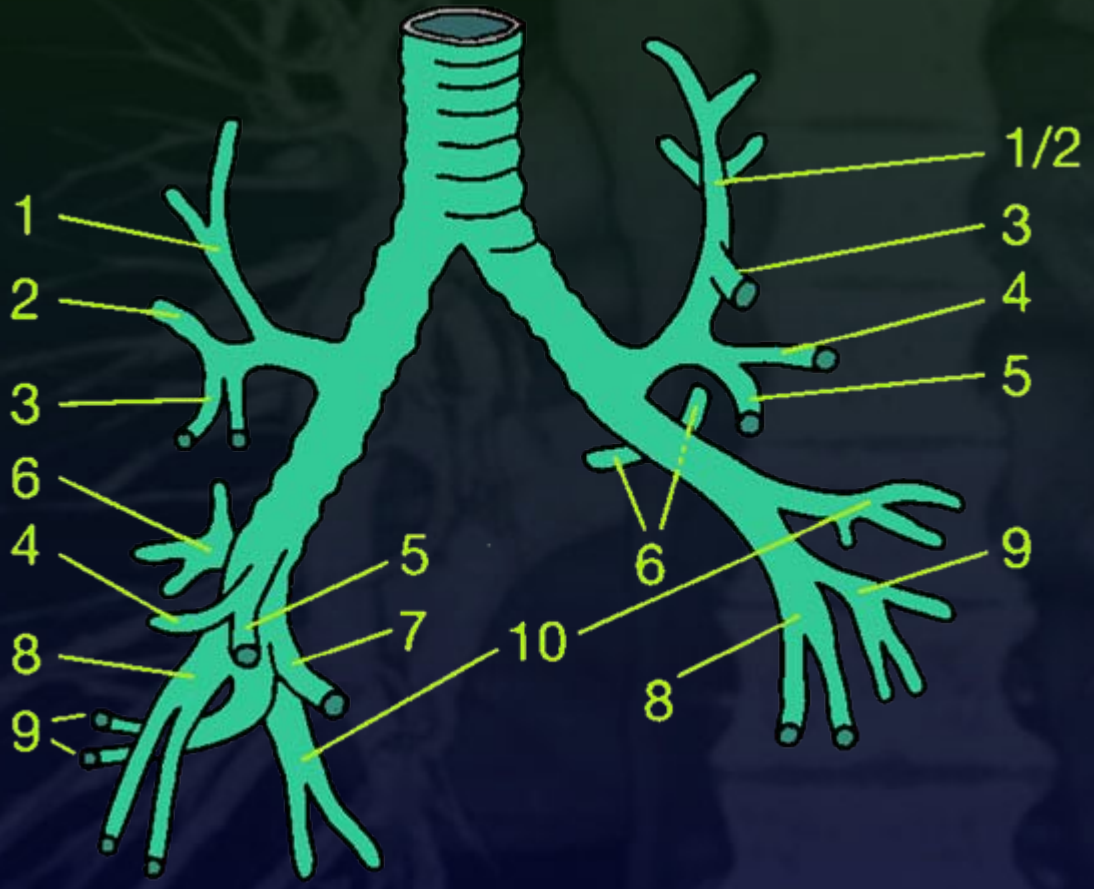






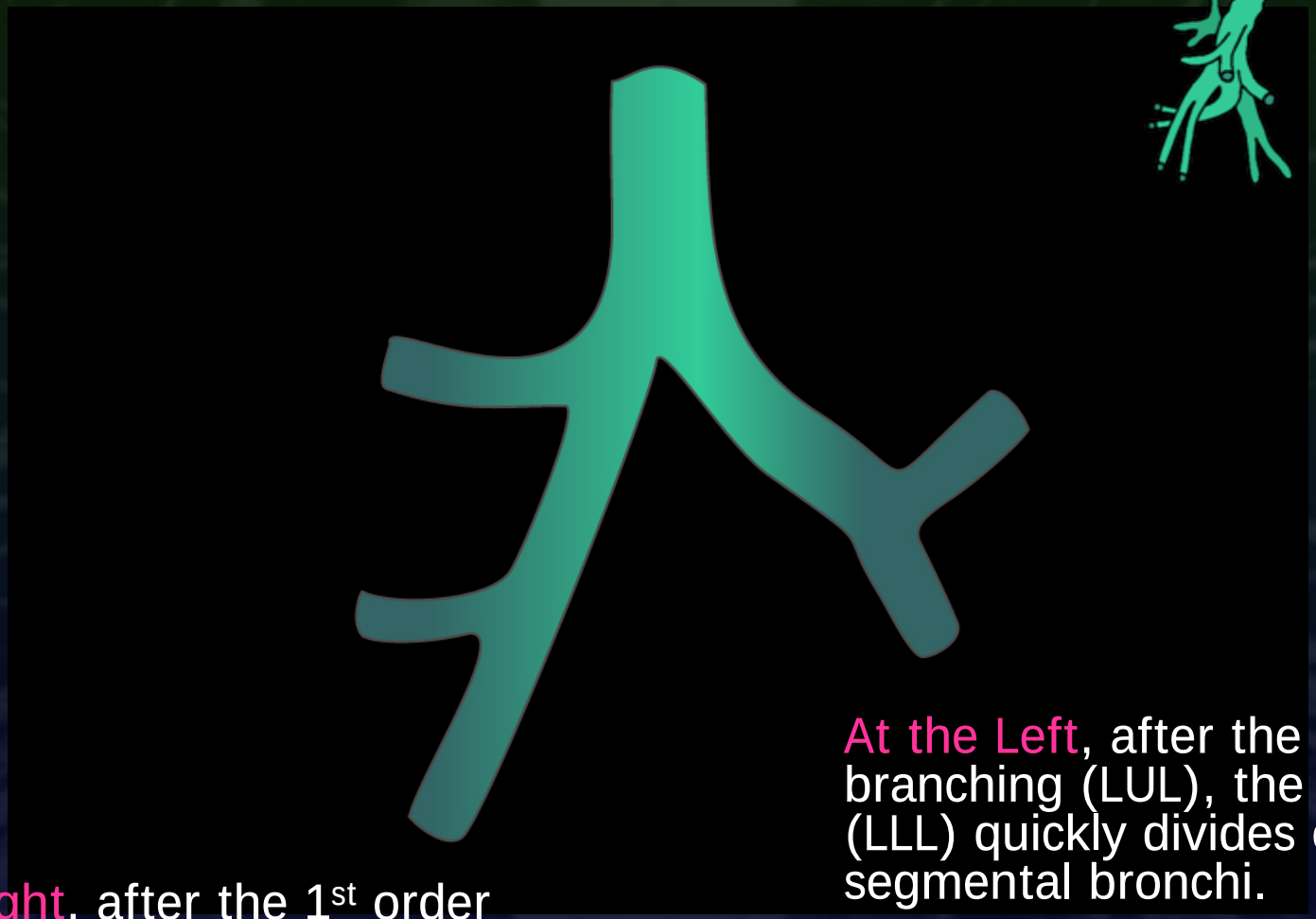


Bronchopulmonary Segments



Upper lobe	1 apical 2 posterior 3 anterior
Middle lobe	4 lateral (superior lingula) 5 medial (inferior lingula)
Lower lobe	6 superior/apical 7 paracardiac/medial basal 8 anterior basal 9 lateral basal 10 posterior basal

Bronchial Divisions



At the Left, after the 1st order branching (LUL), the bronchus (LLL) quickly divides out into segmental bronchi.

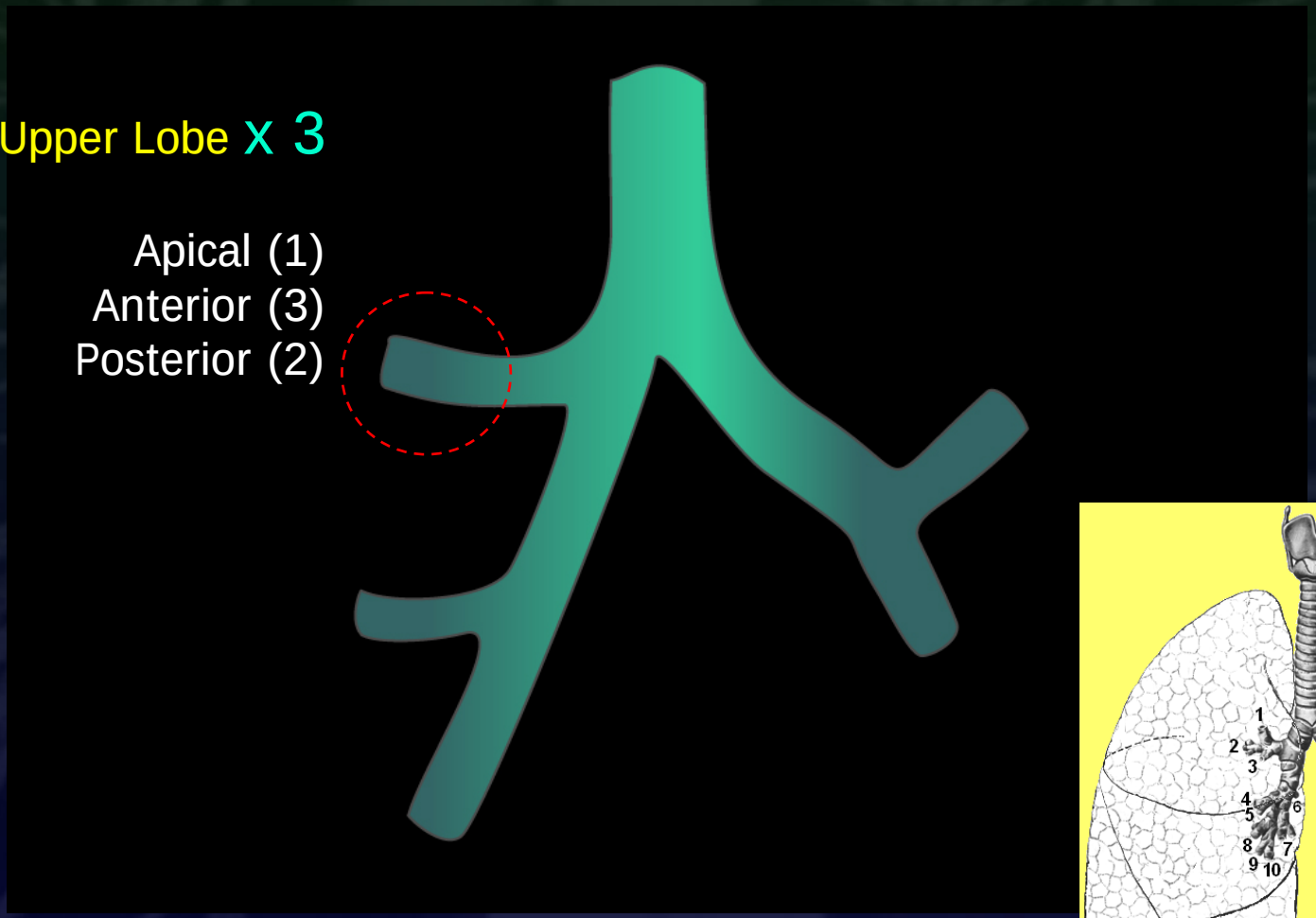
At the Right, after the 1st order branching (RUL), the bronchus travels for a distance (bronchus intermedius) before the 2nd order branching (RML & RLL).

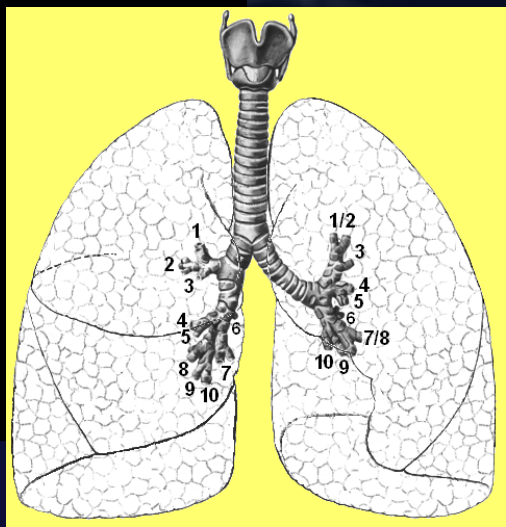
Bronchopulmonary Segments

There is no easy way to remember these. We try our best!
Thankfully we can usually identify the major segmental branches on CT.

Rt Upper Lobe x 3

Apical (1)
Anterior (3)
Posterior (2)

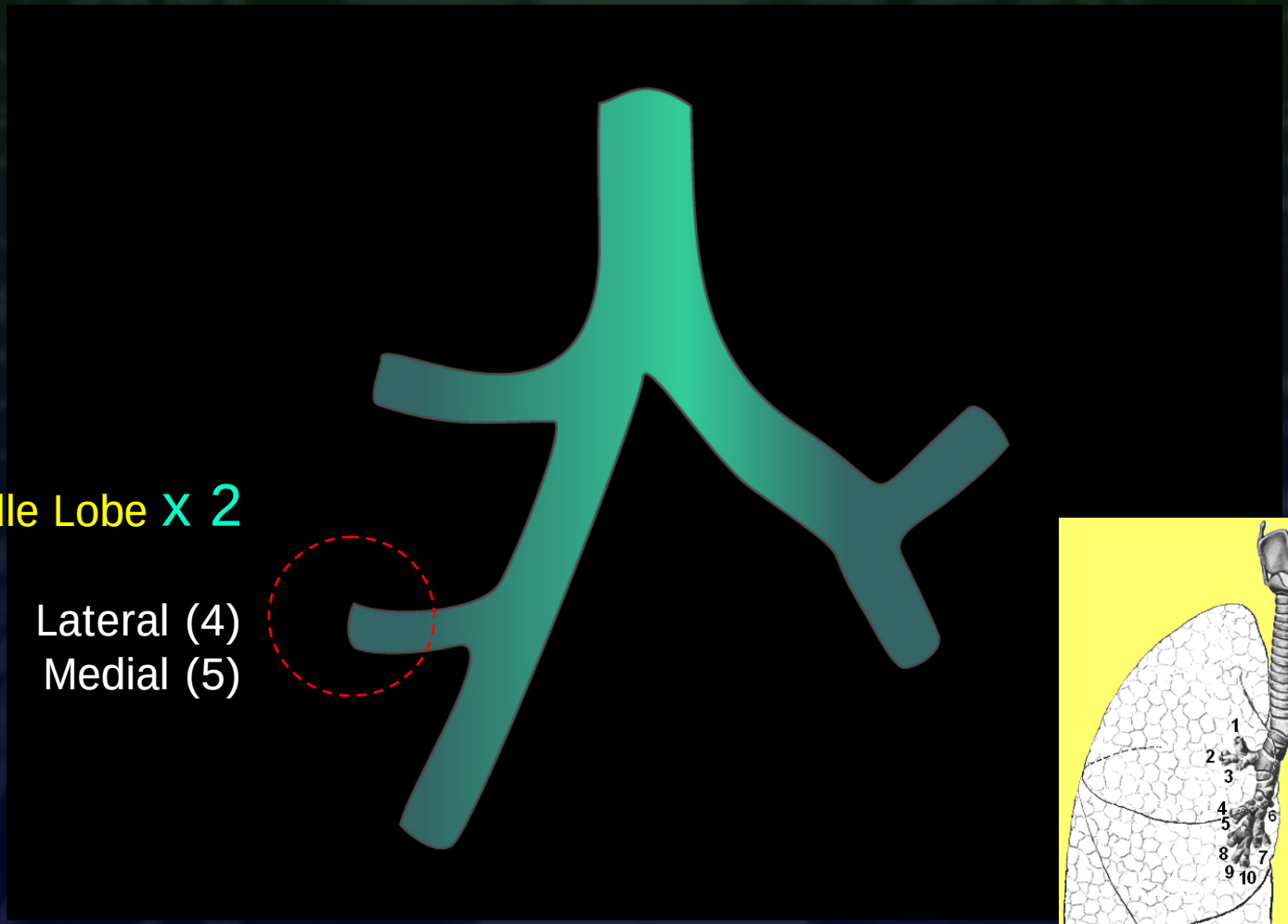


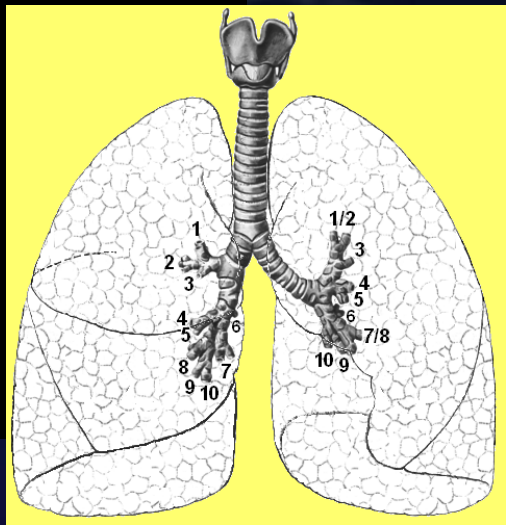


Bronchopulmonary Segments

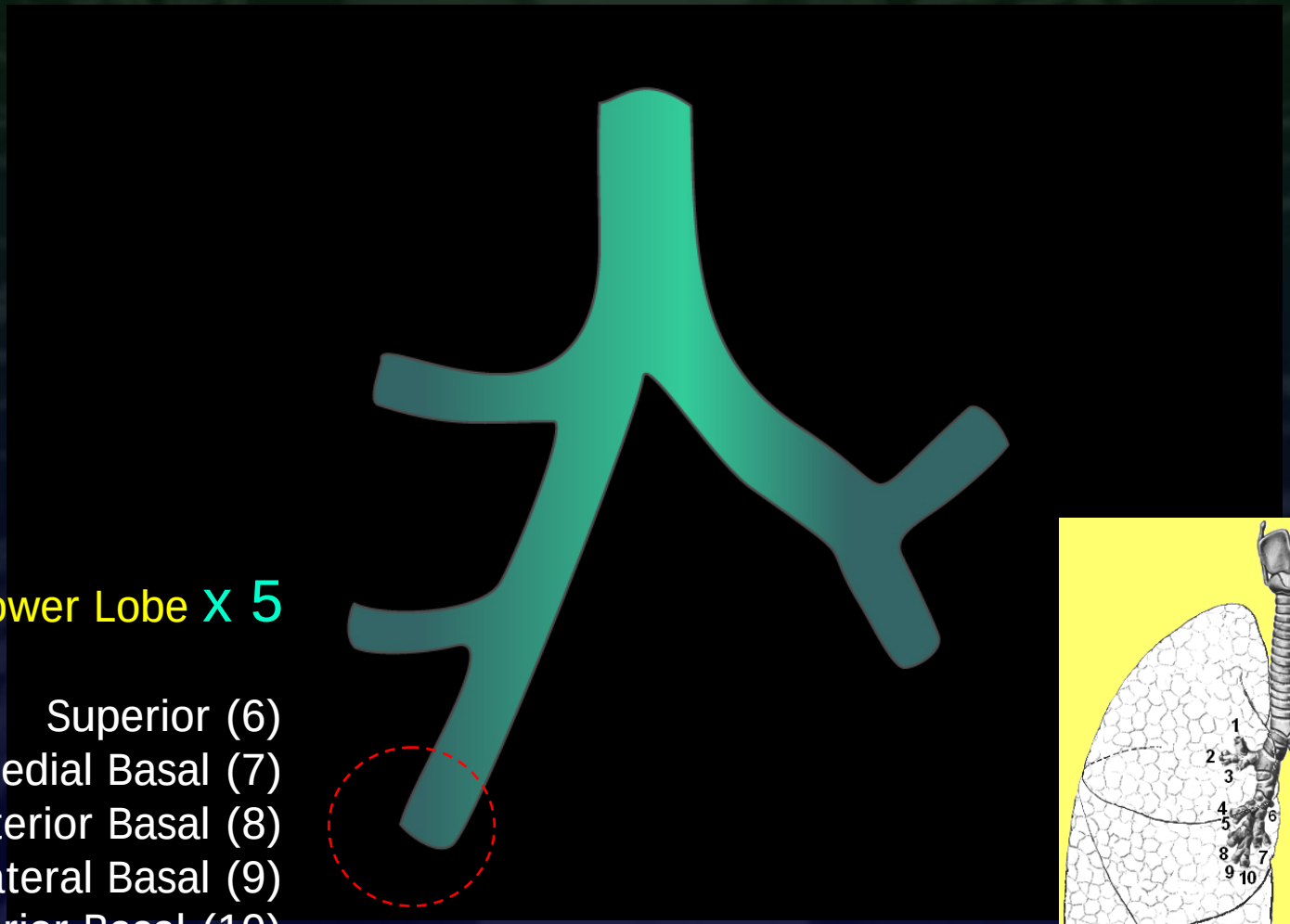
Rt Middle Lobe x 2

Lateral (4)
Medial (5)



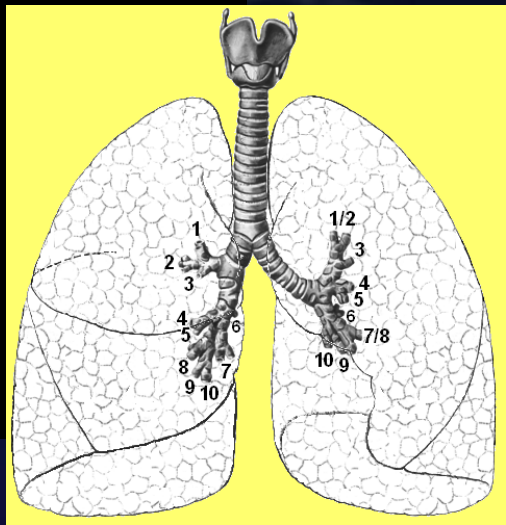


Bronchopulmonary Segments



Rt Lower Lobe x 5

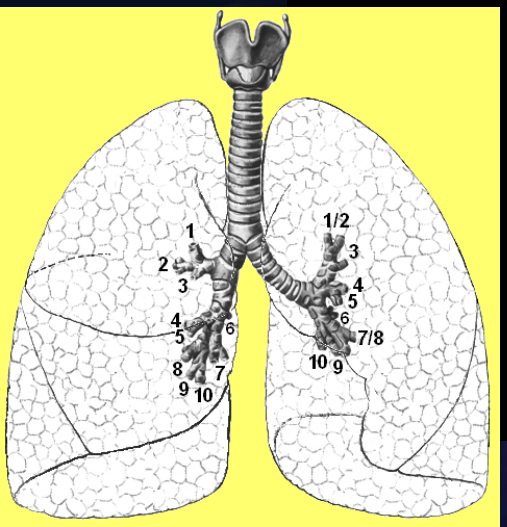
Superior (6)
Medial Basal (7)
Anterior Basal (8)
Lateral Basal (9)
Posterior Basal (10)



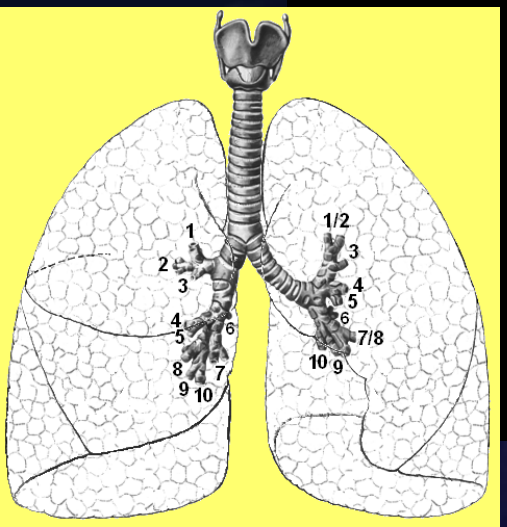
Bronchopulmonary Segments

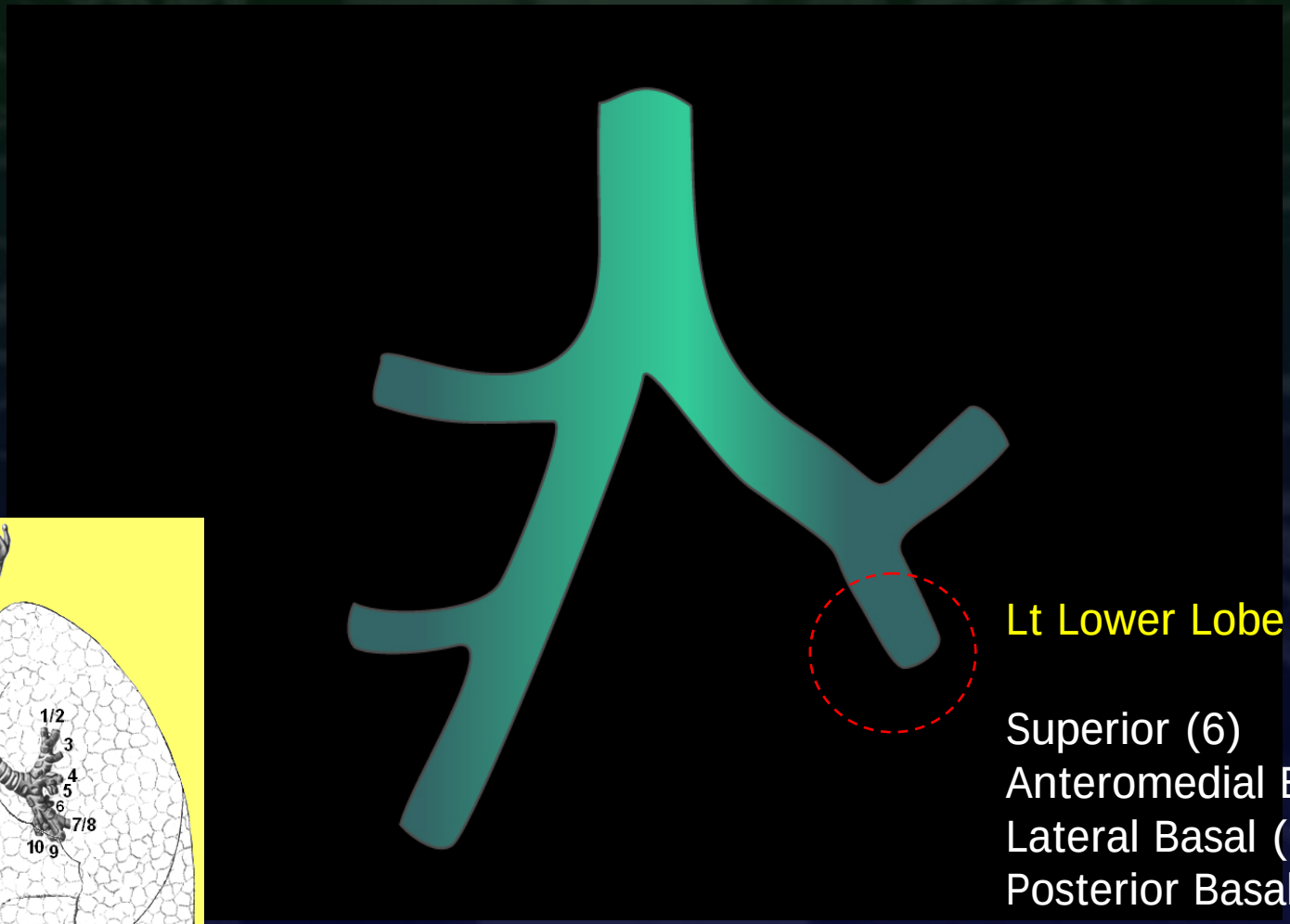
Lt Upper Lobe x 3

Apicoposterior (1/2)
Anterior (3)
Lingular segment : has 2 divisions: sup (4) & inf (5)



Bronchopulmonary Segments





Lt Lower Lobe x 4

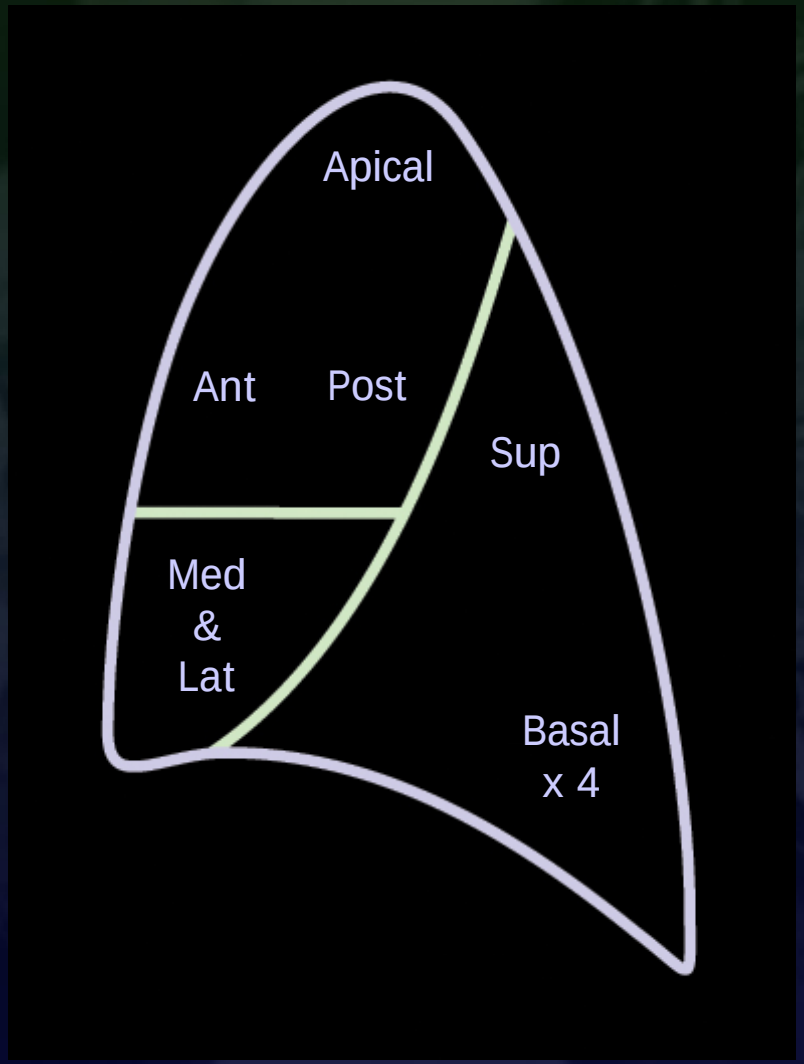
Superior (6)
Anteromedial Basal (7/8)
Lateral Basal (9)
Posterior Basal (10)

Bronchopulmonary Segments: Right

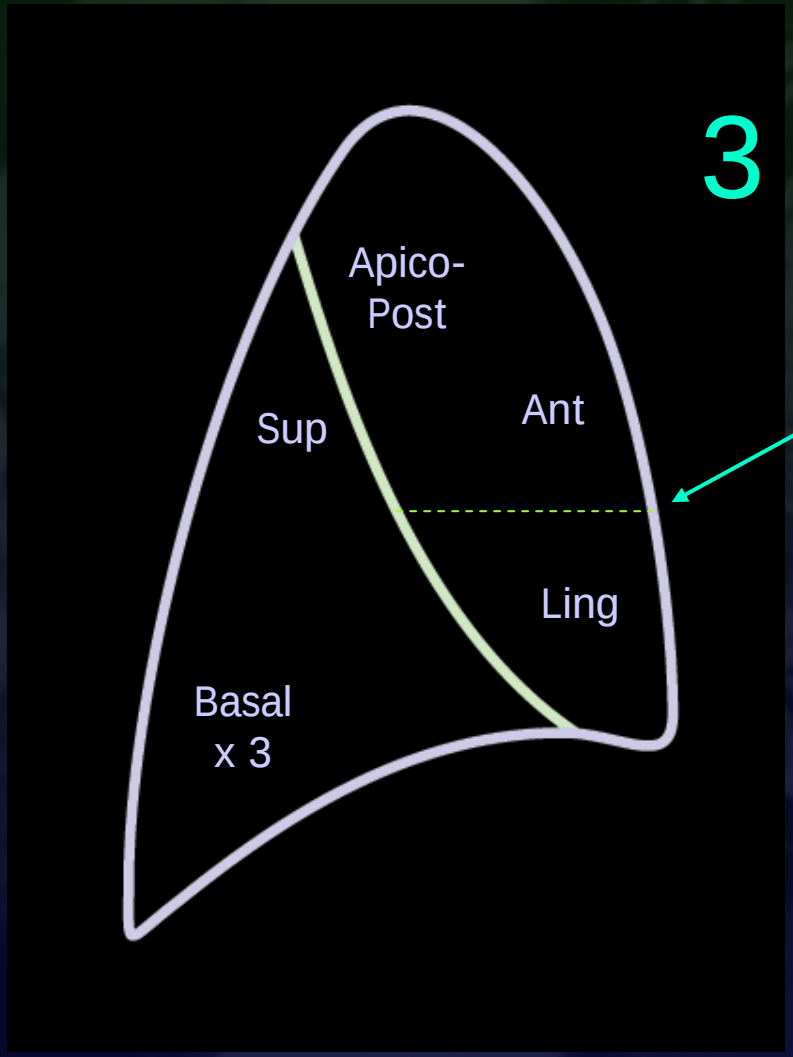
3

2

5



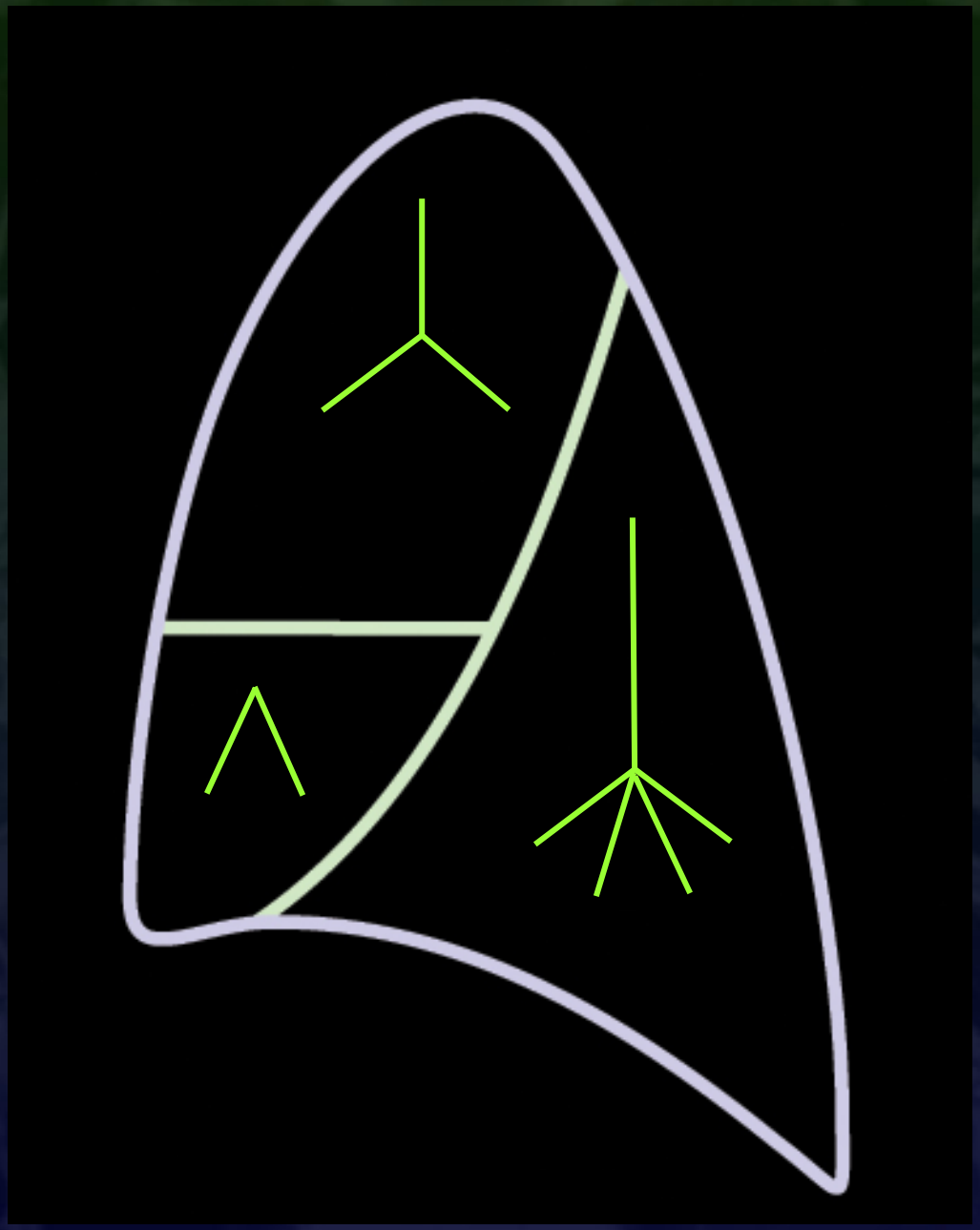
Bronchopulmonary Segments: Left



Think of an imaginary left horizontal fissure: "Left lung trying to have a middle lobe"!

Right

3

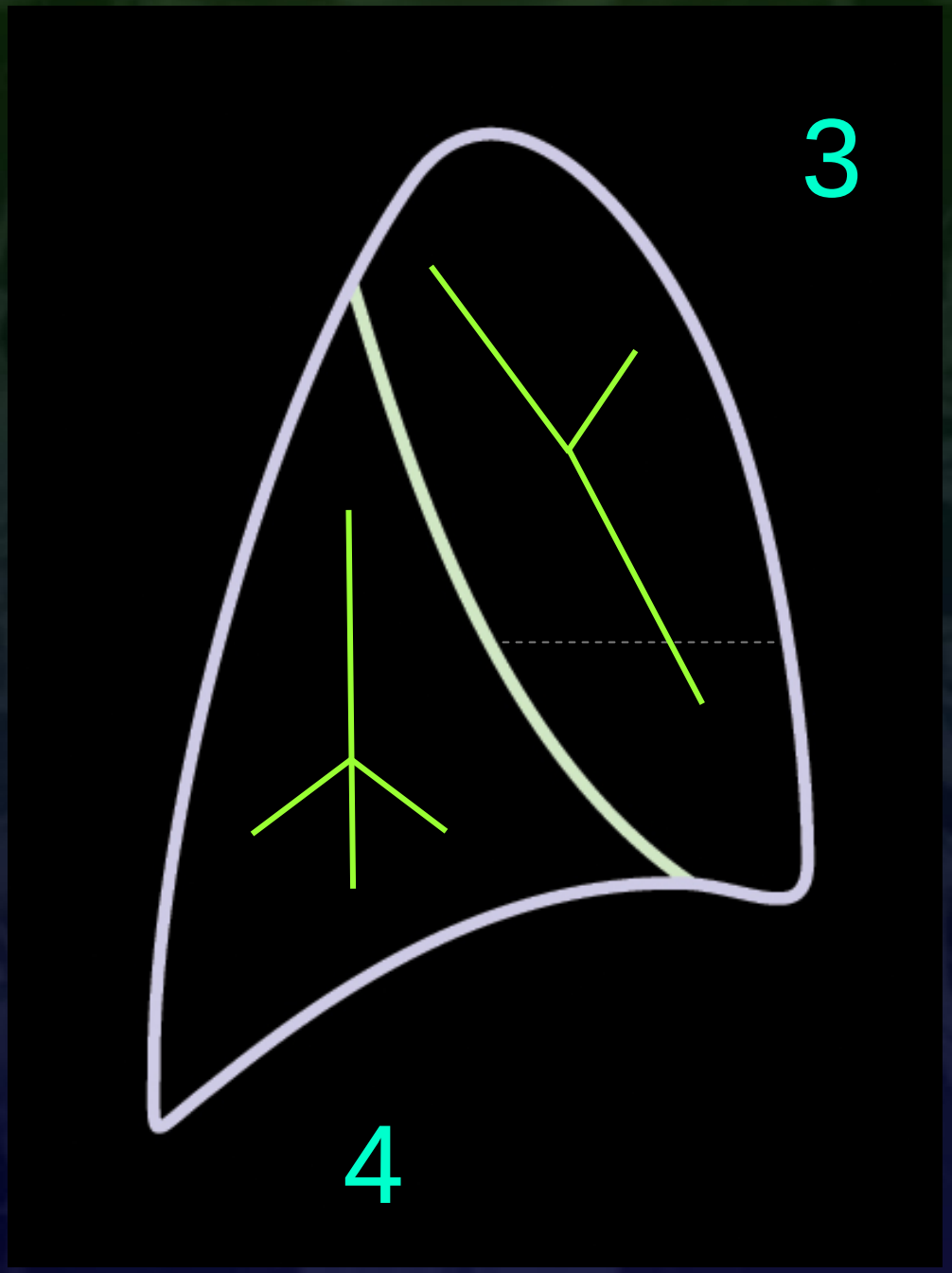


2

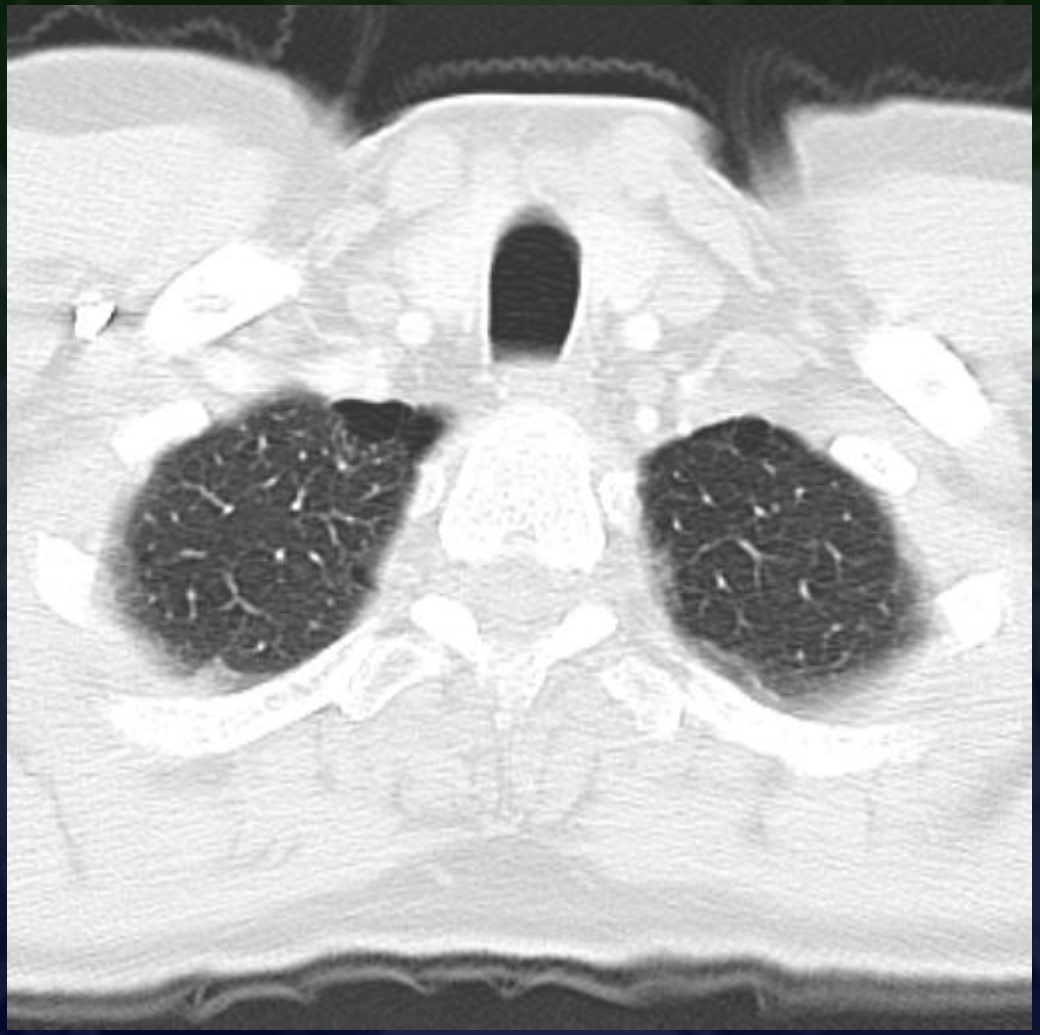
5

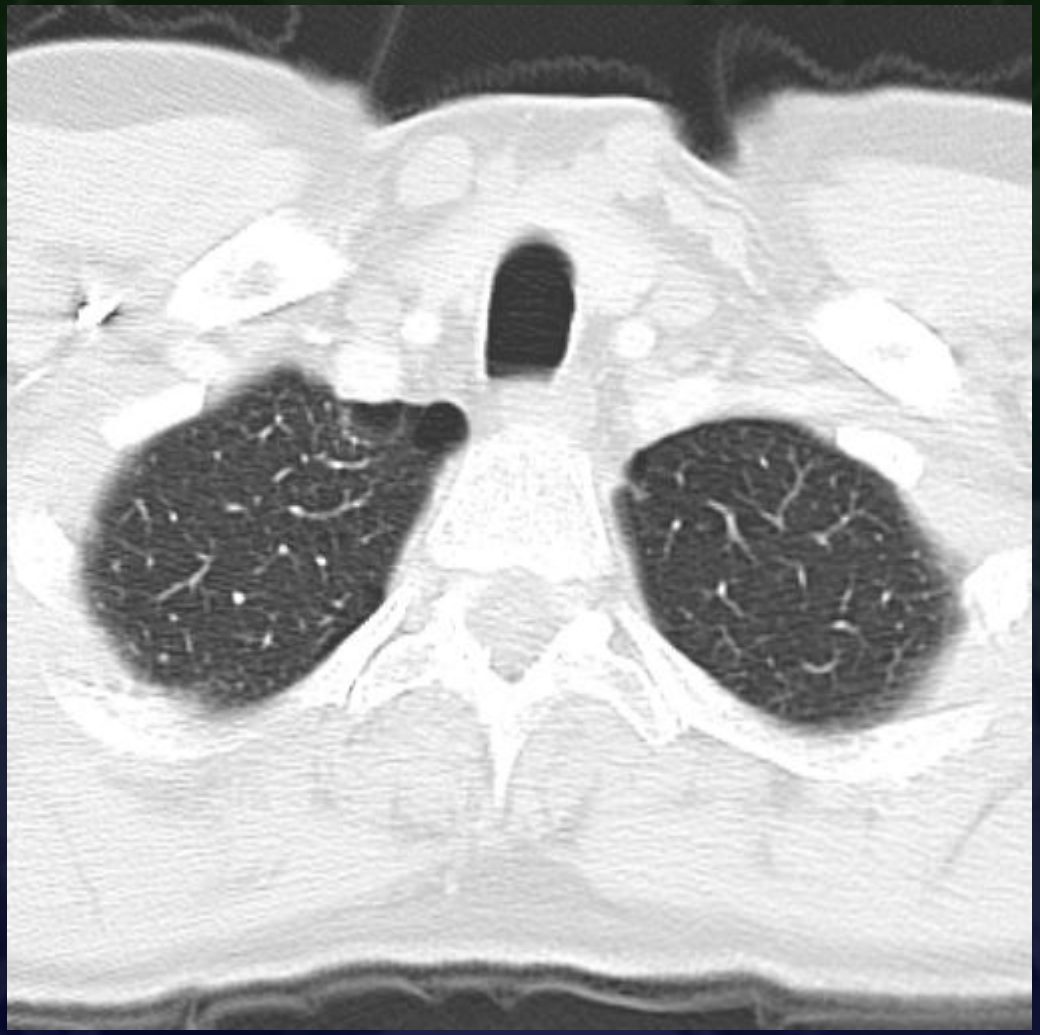
My lame attempt at making it easier to remember!

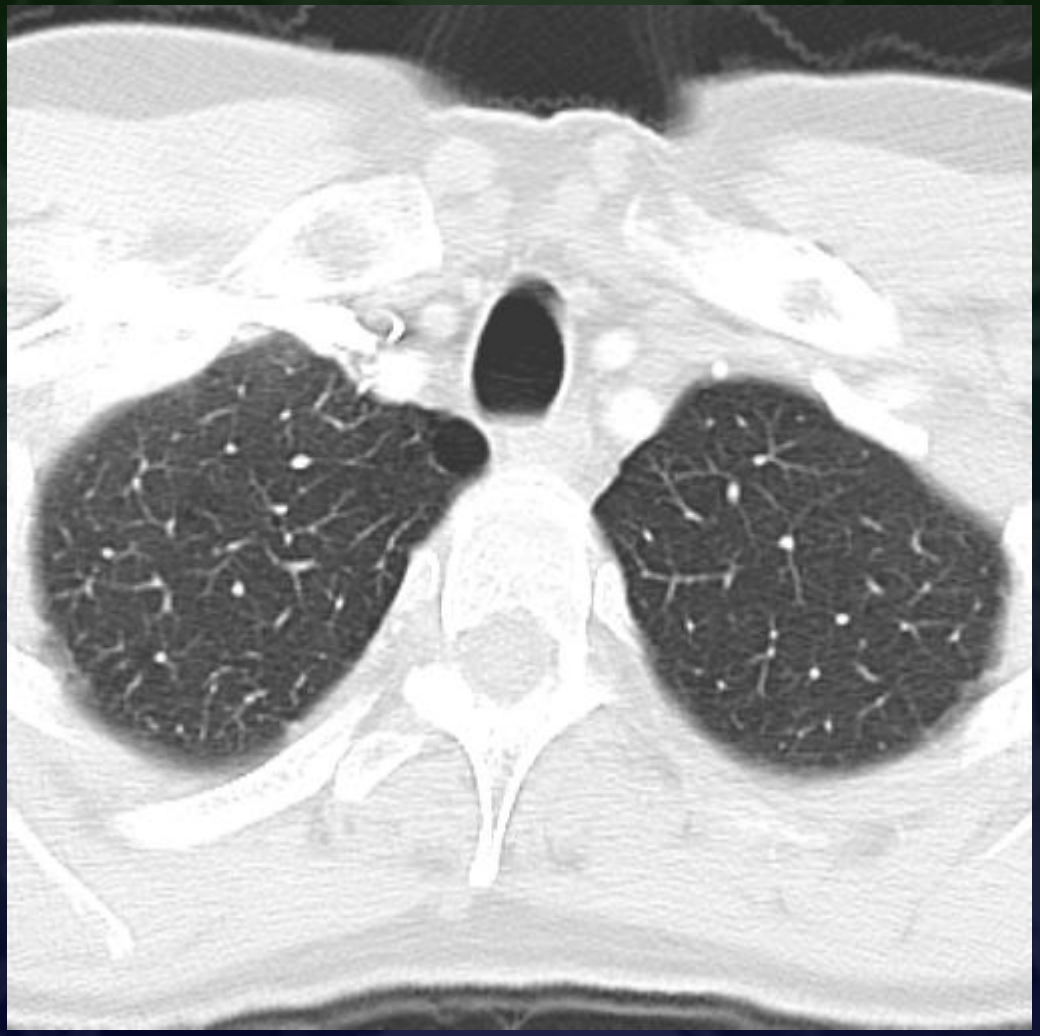
Left

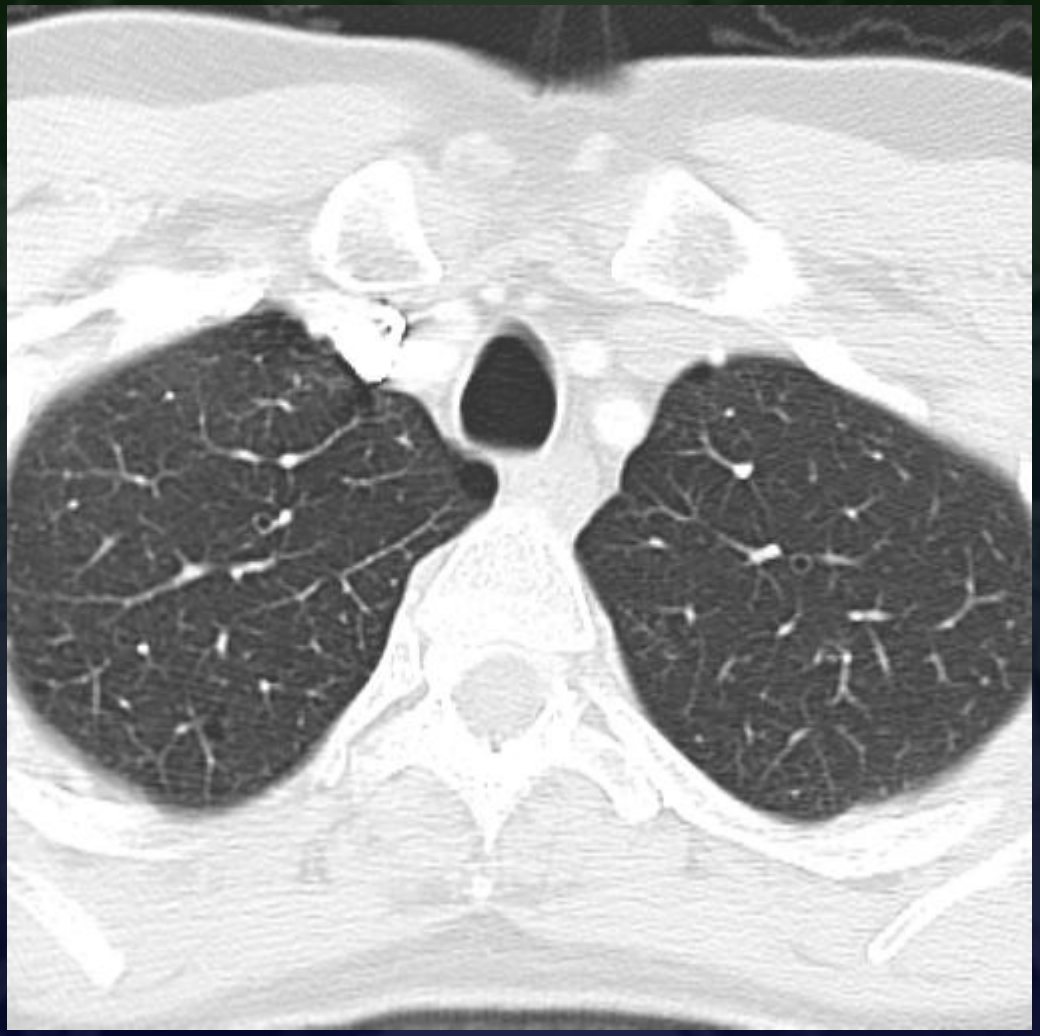


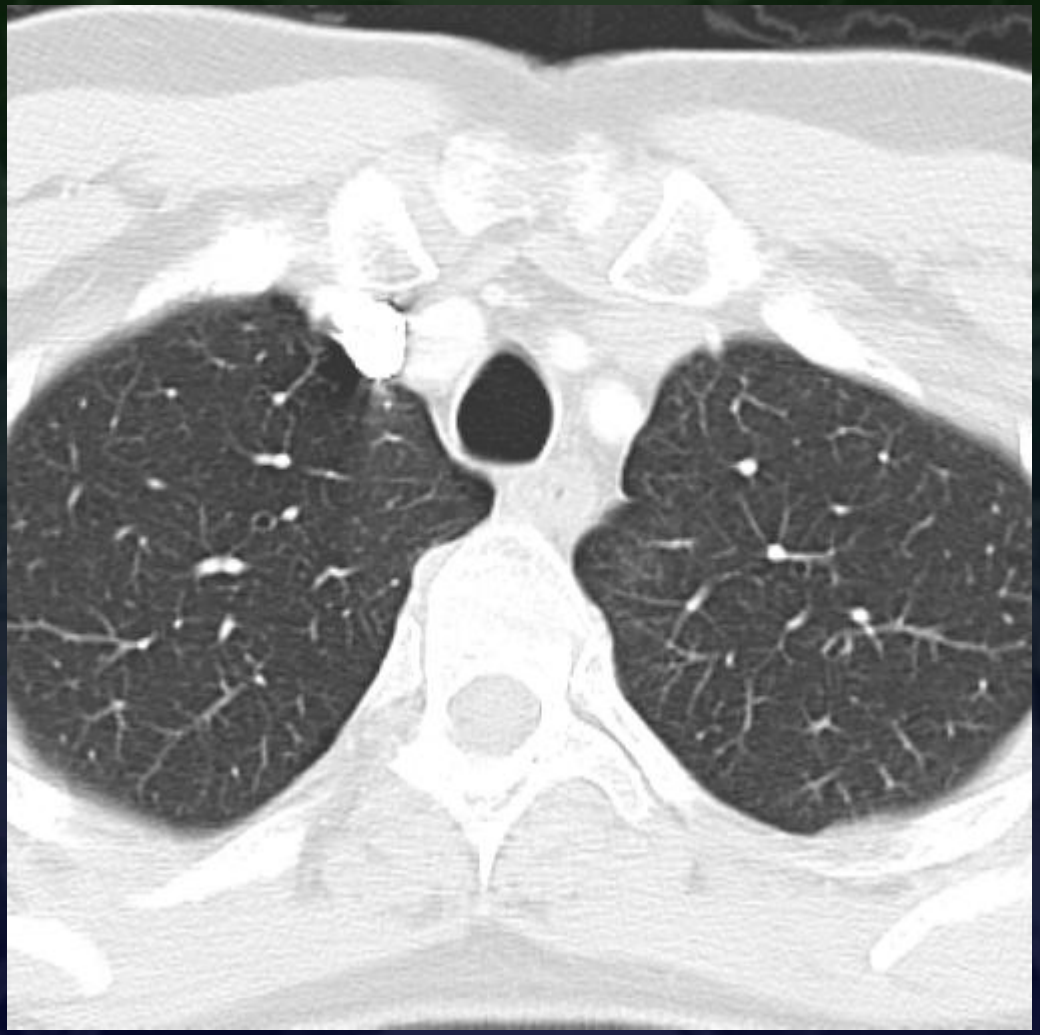
Bronchopulmonary Segments

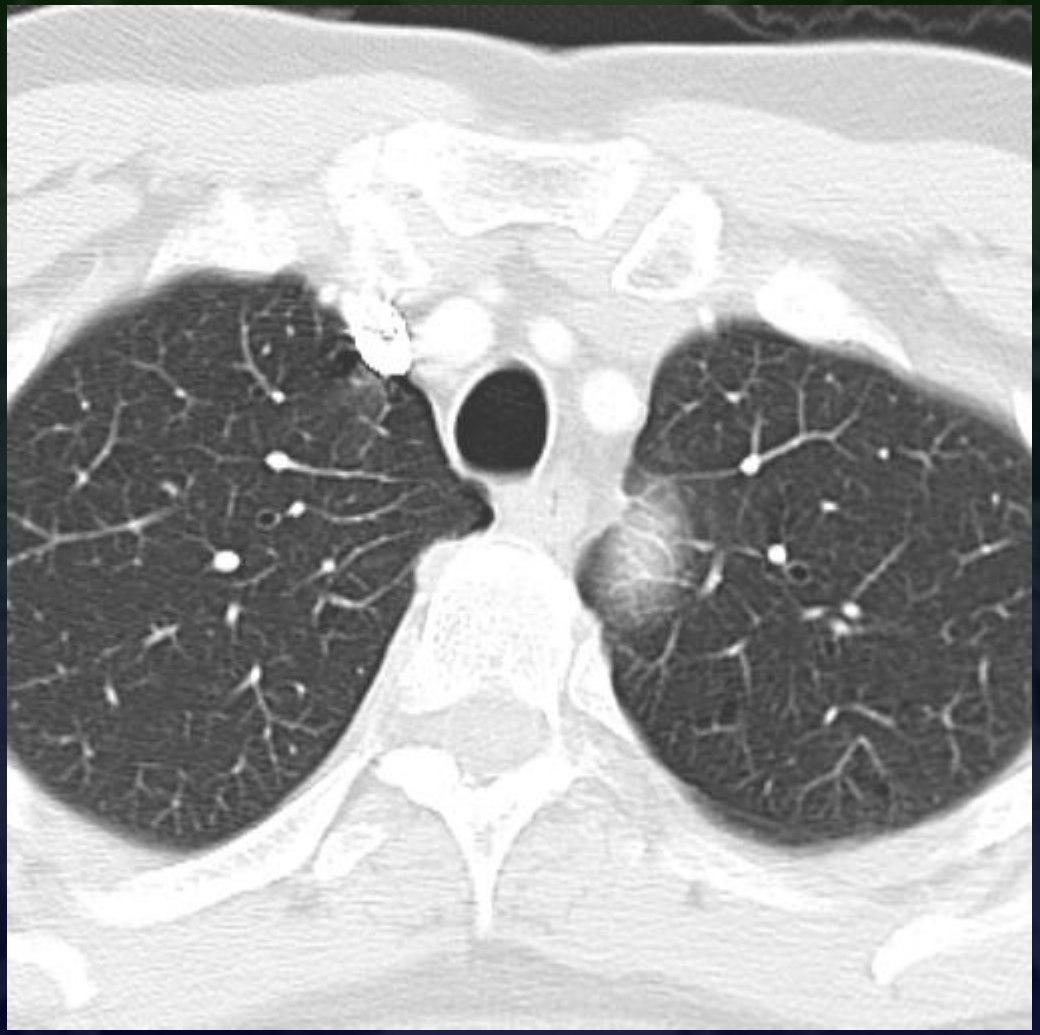


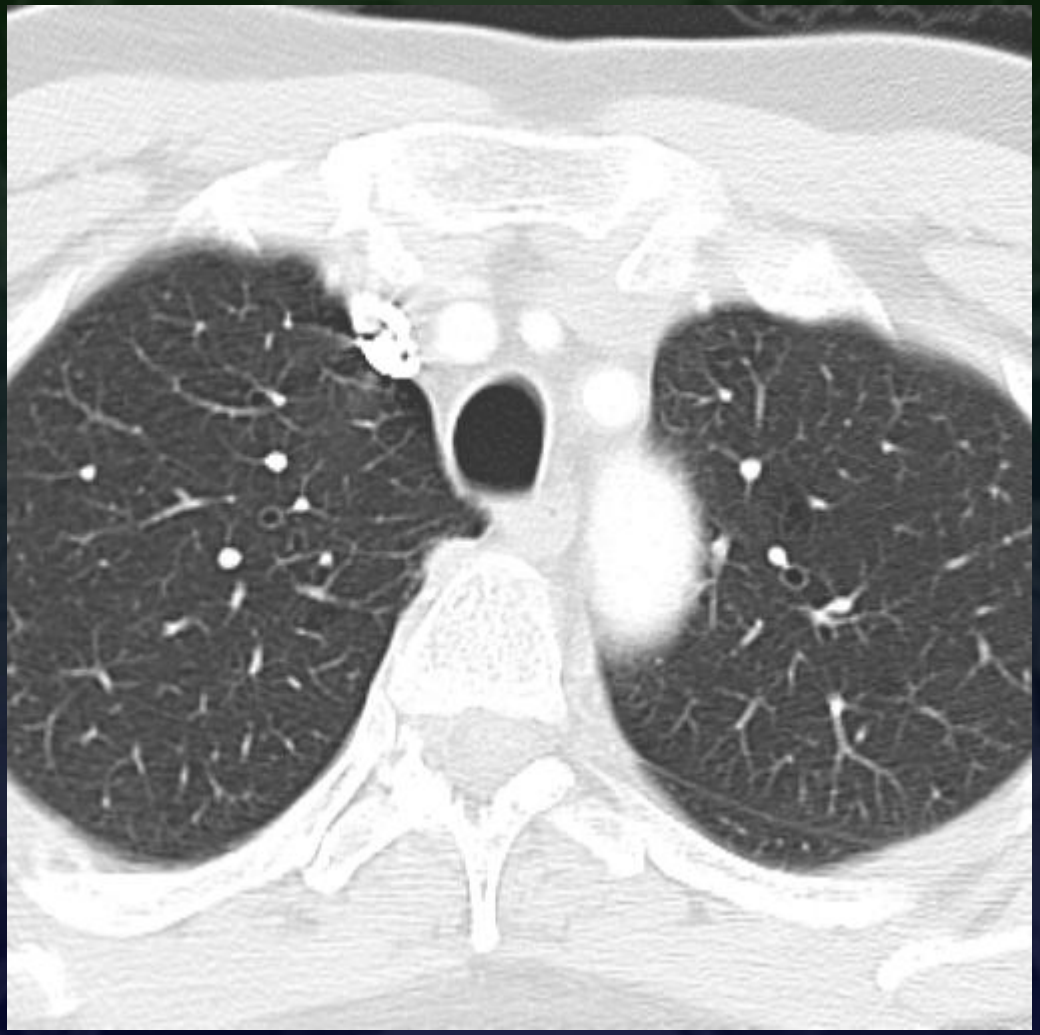


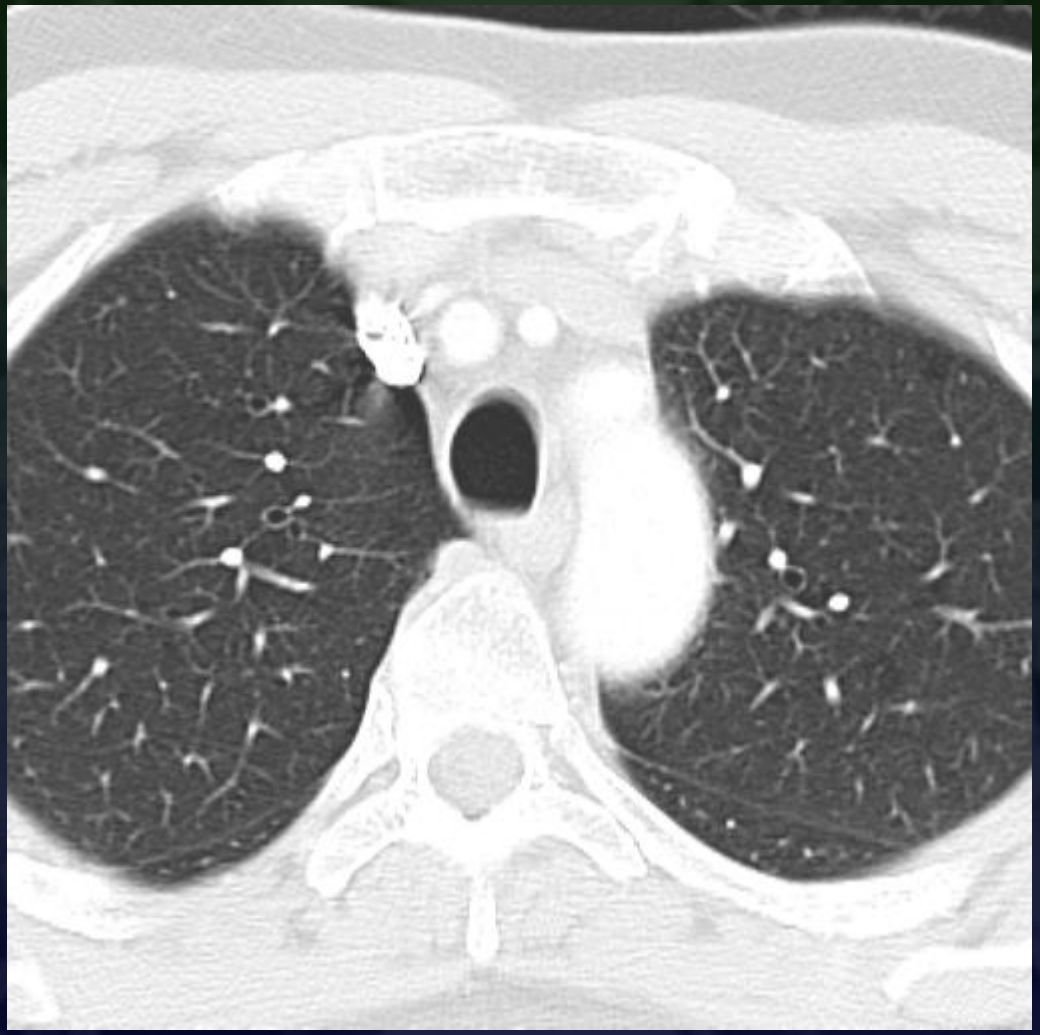


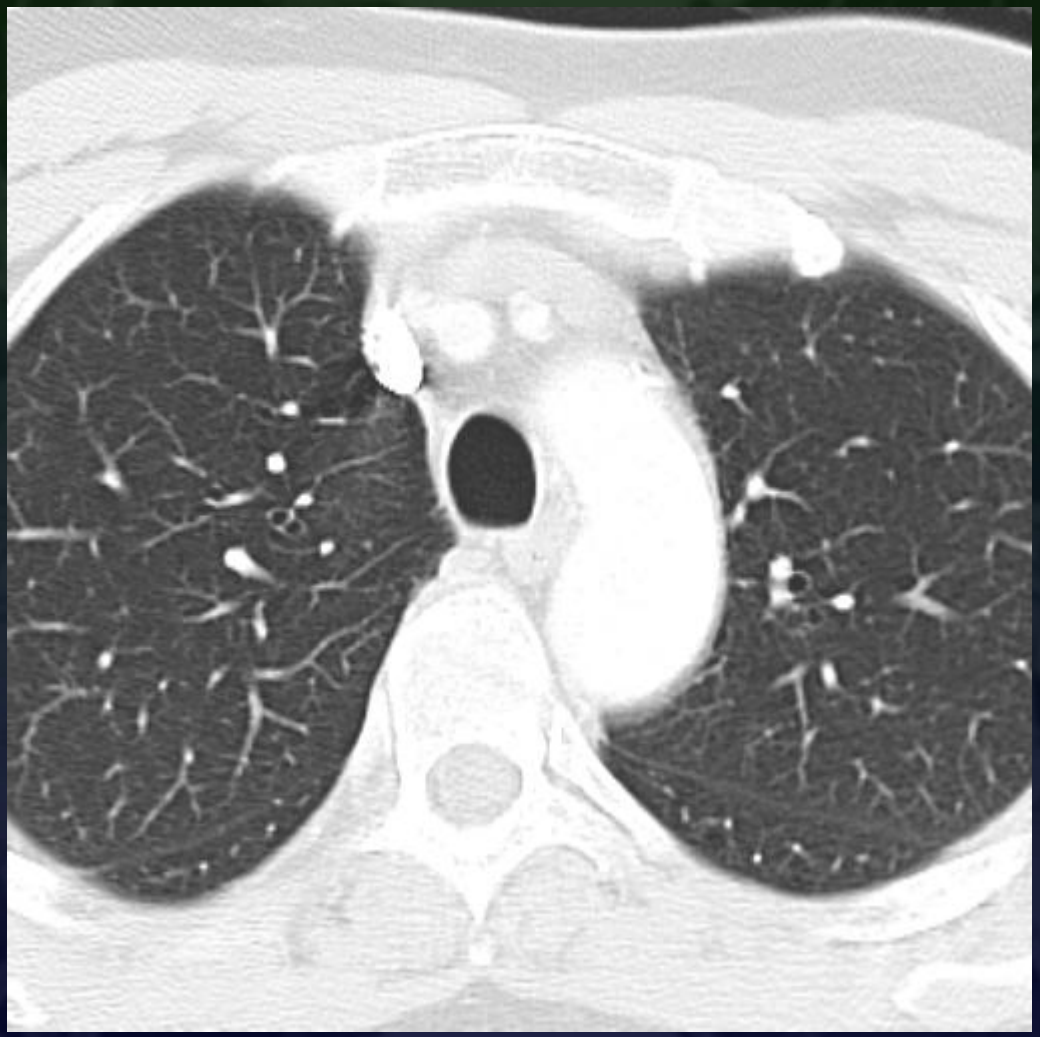


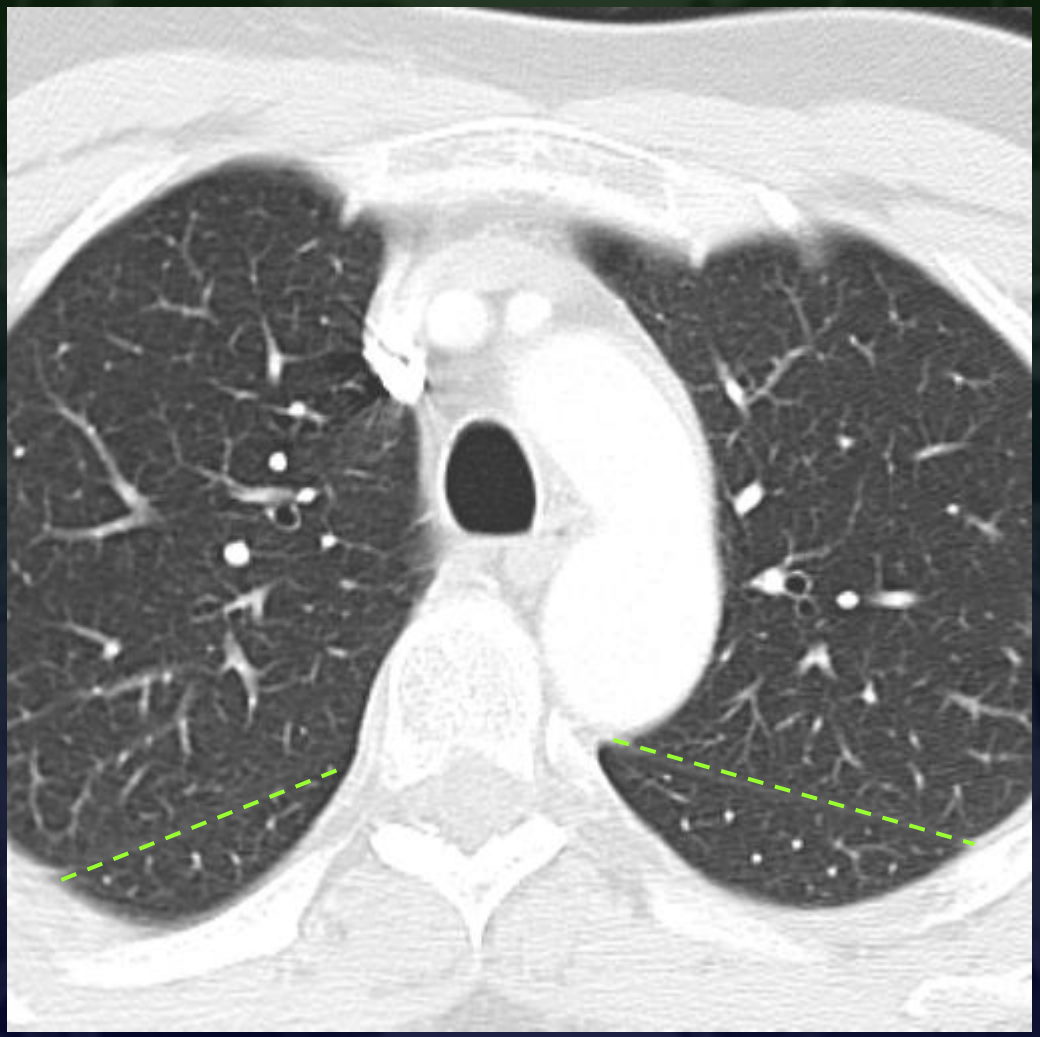


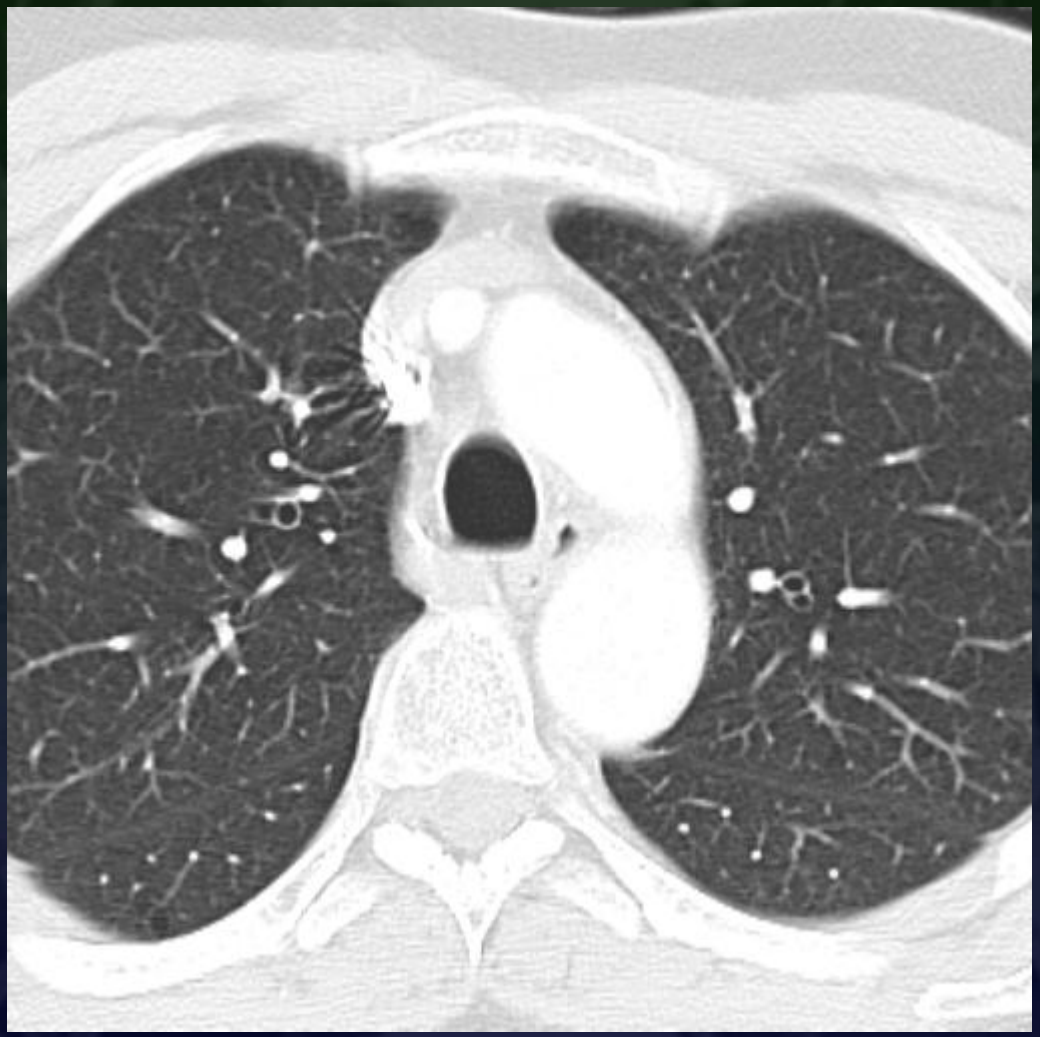


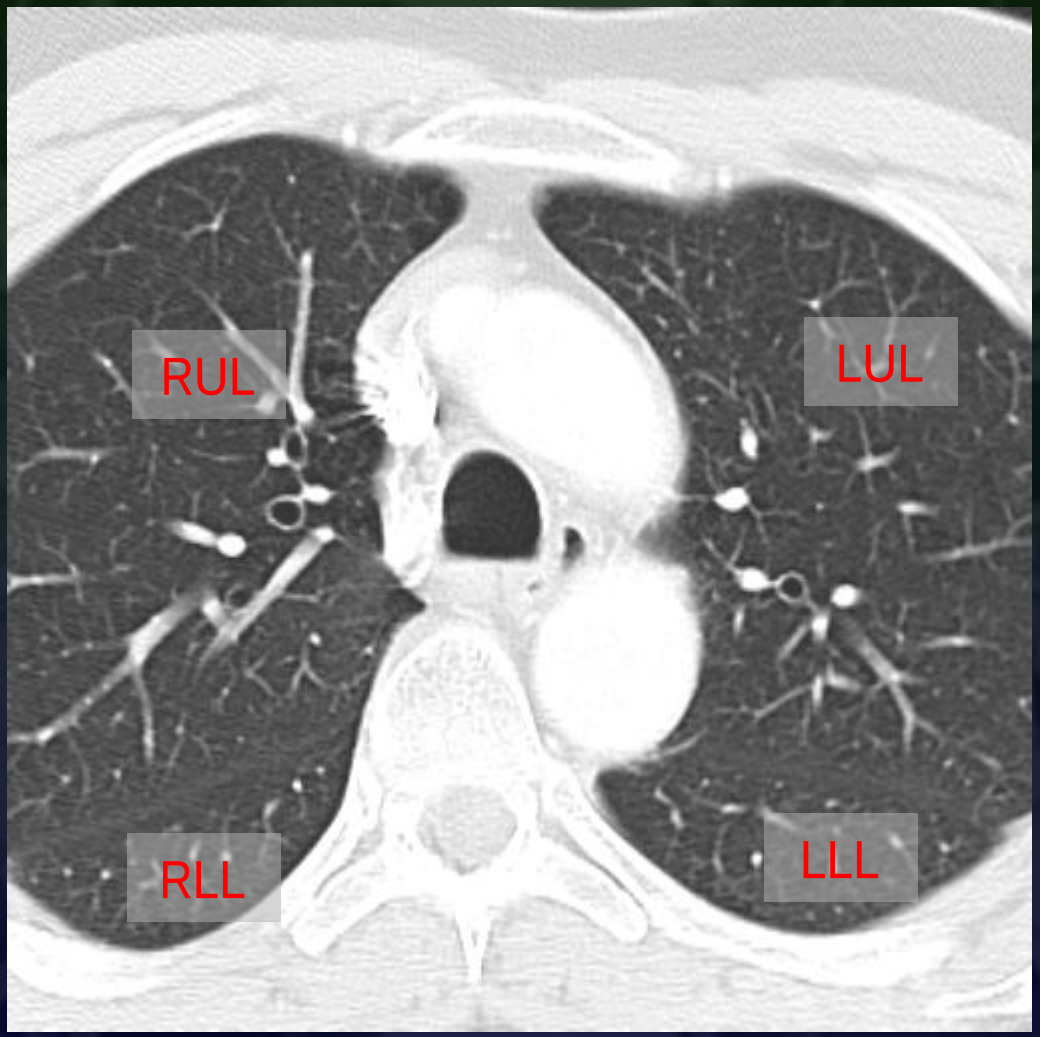


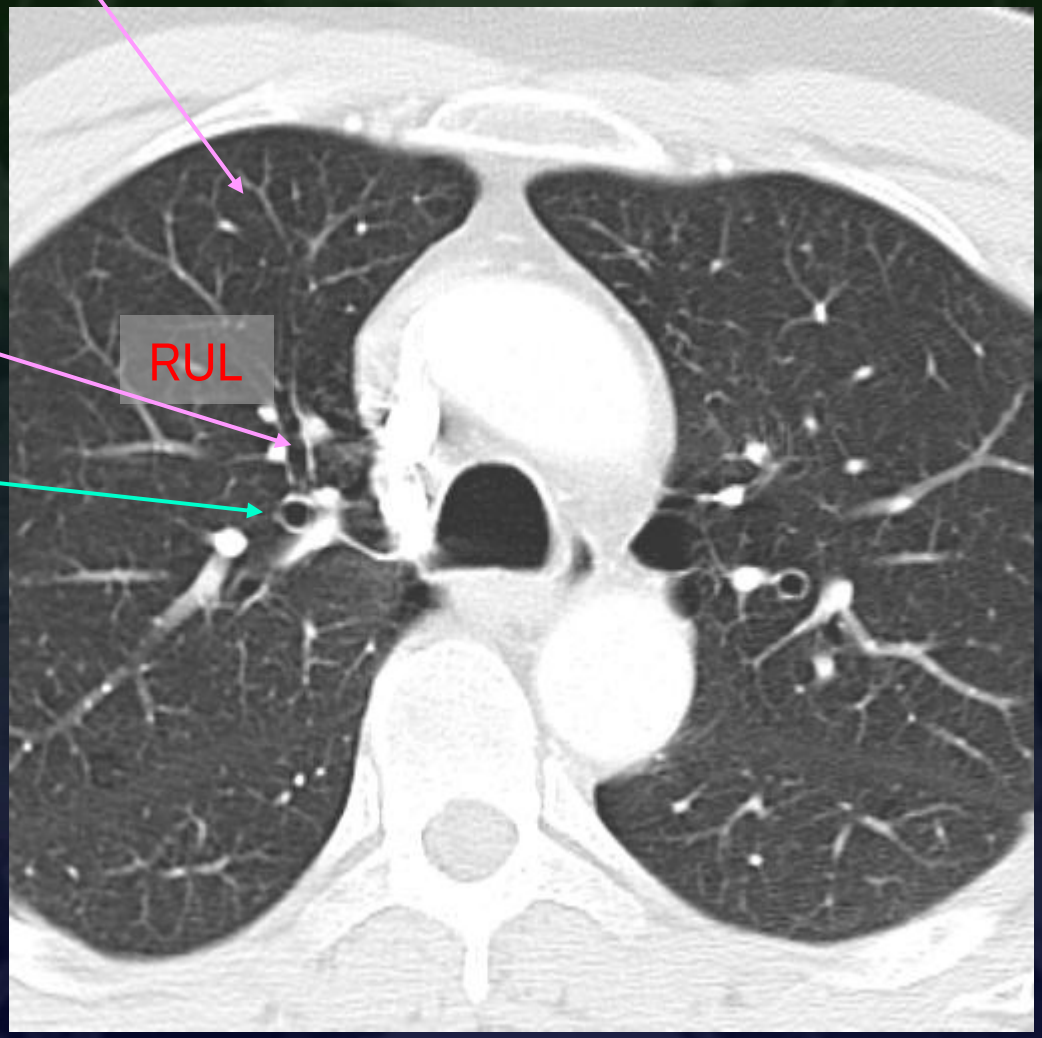


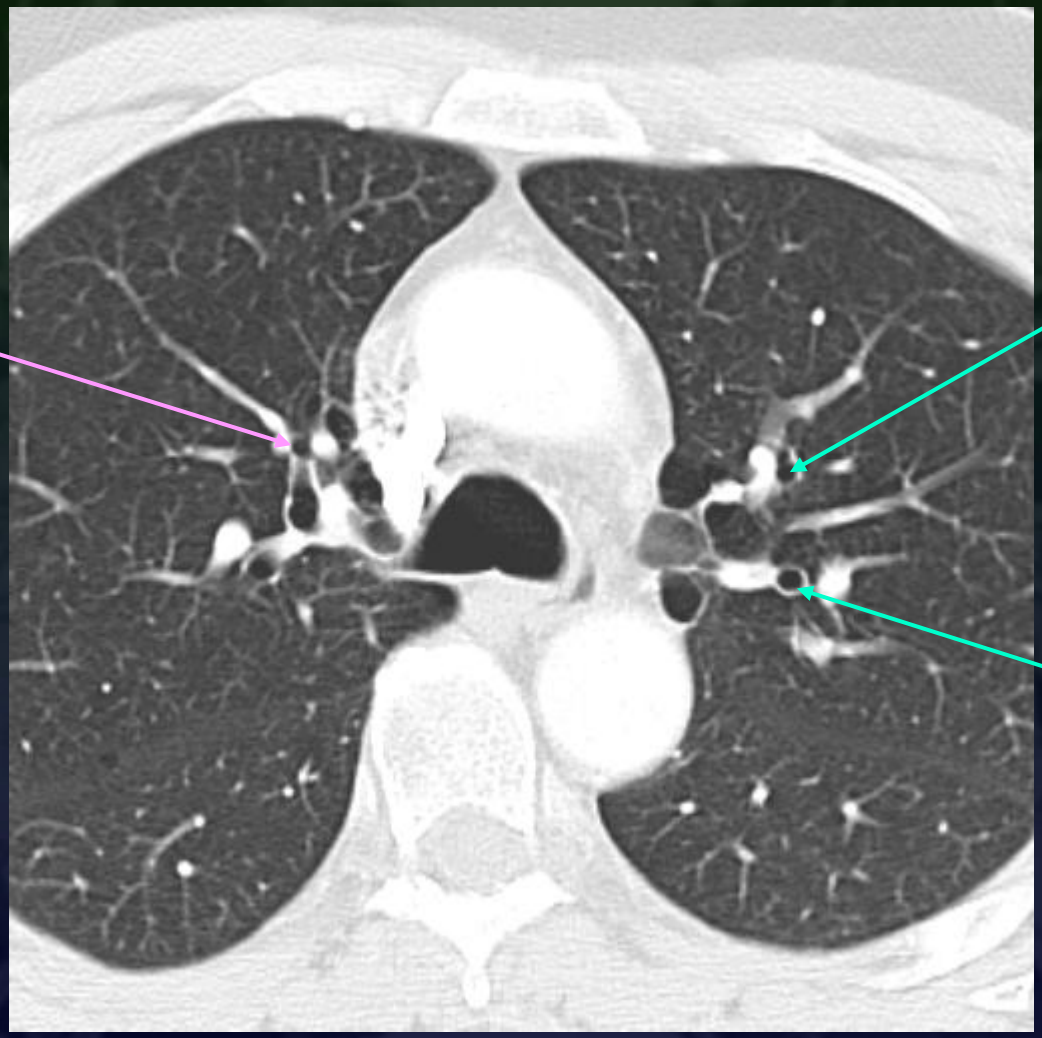


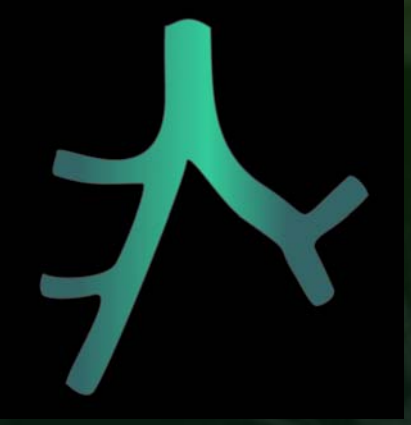





RUL
LUL
RLL
LLL

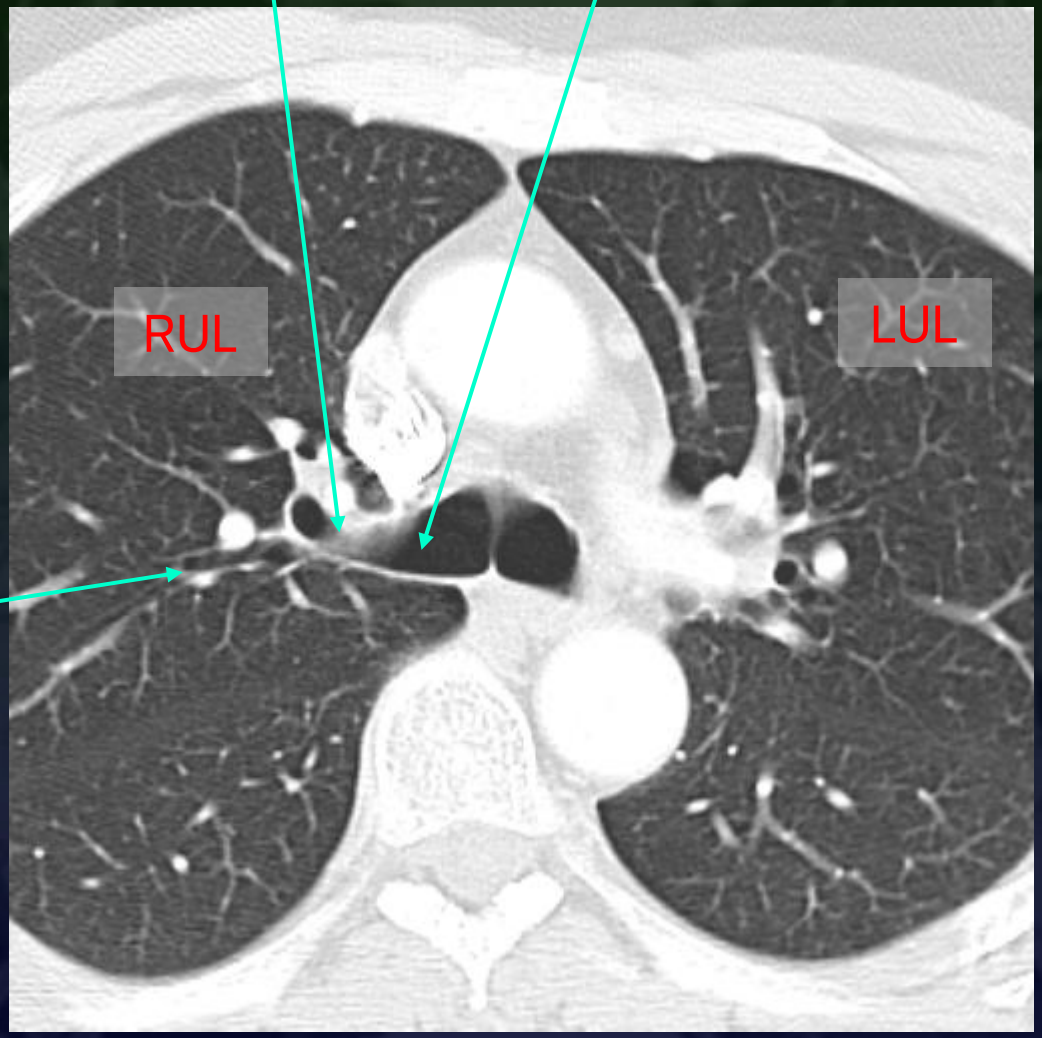

Ant. seg.
upper lobe
Ant. seg.
bronchus
apical
RUL


Ant. seg. bronchus
anterior
apicoposterior



RUL Bronchus

Right Main Bronchus

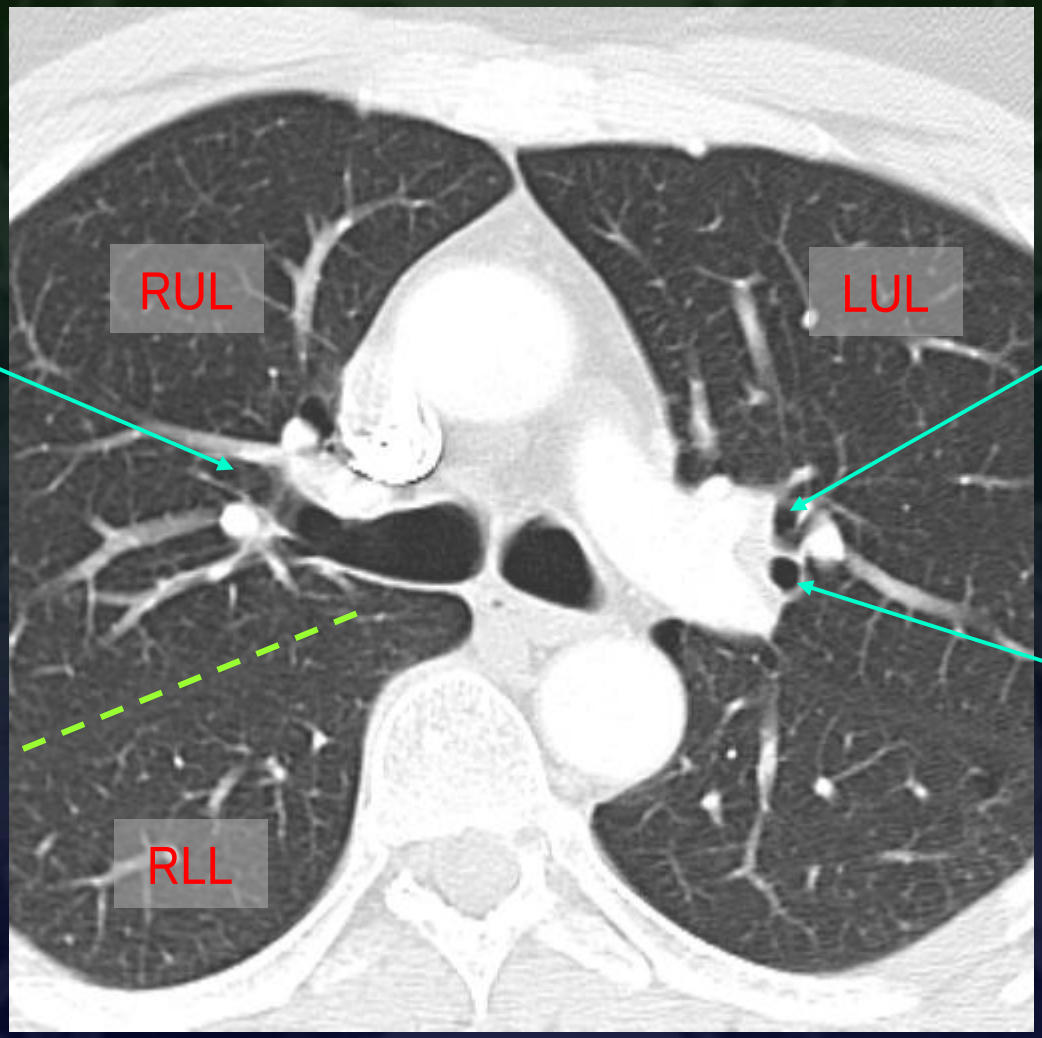


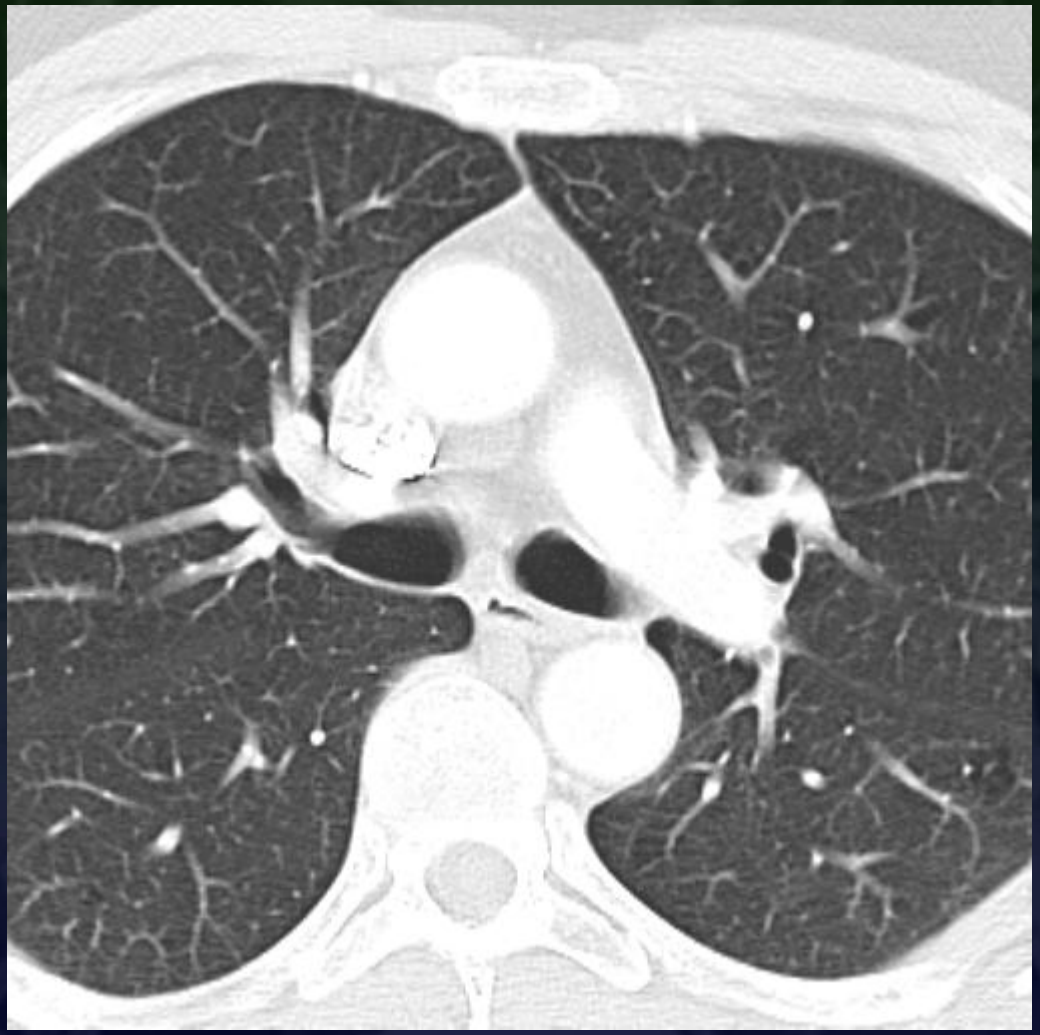
posterior

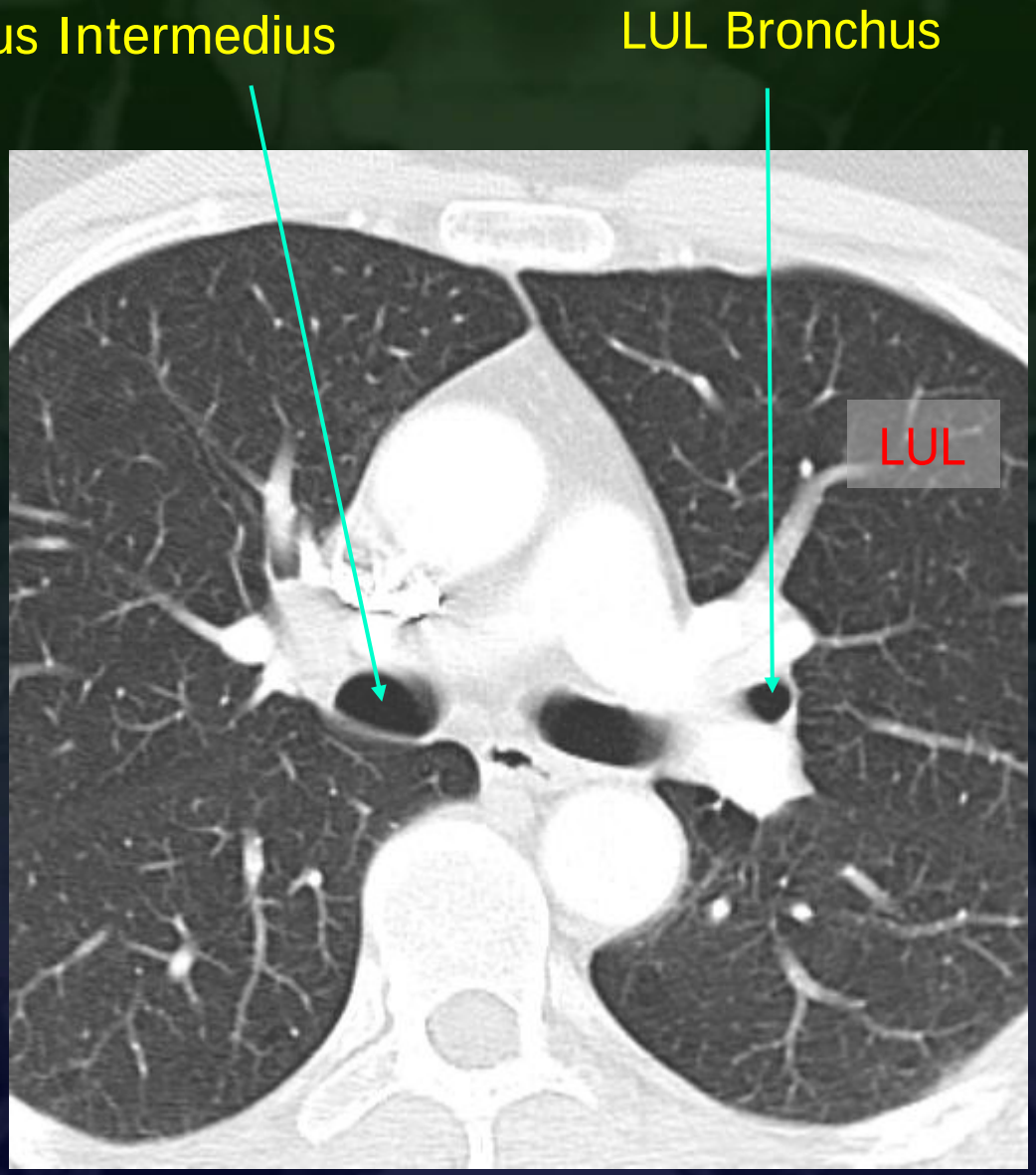
Rt main bronchus -→ (1st pinch) --→ RUL bronchus → ant, apical and post segmental branches

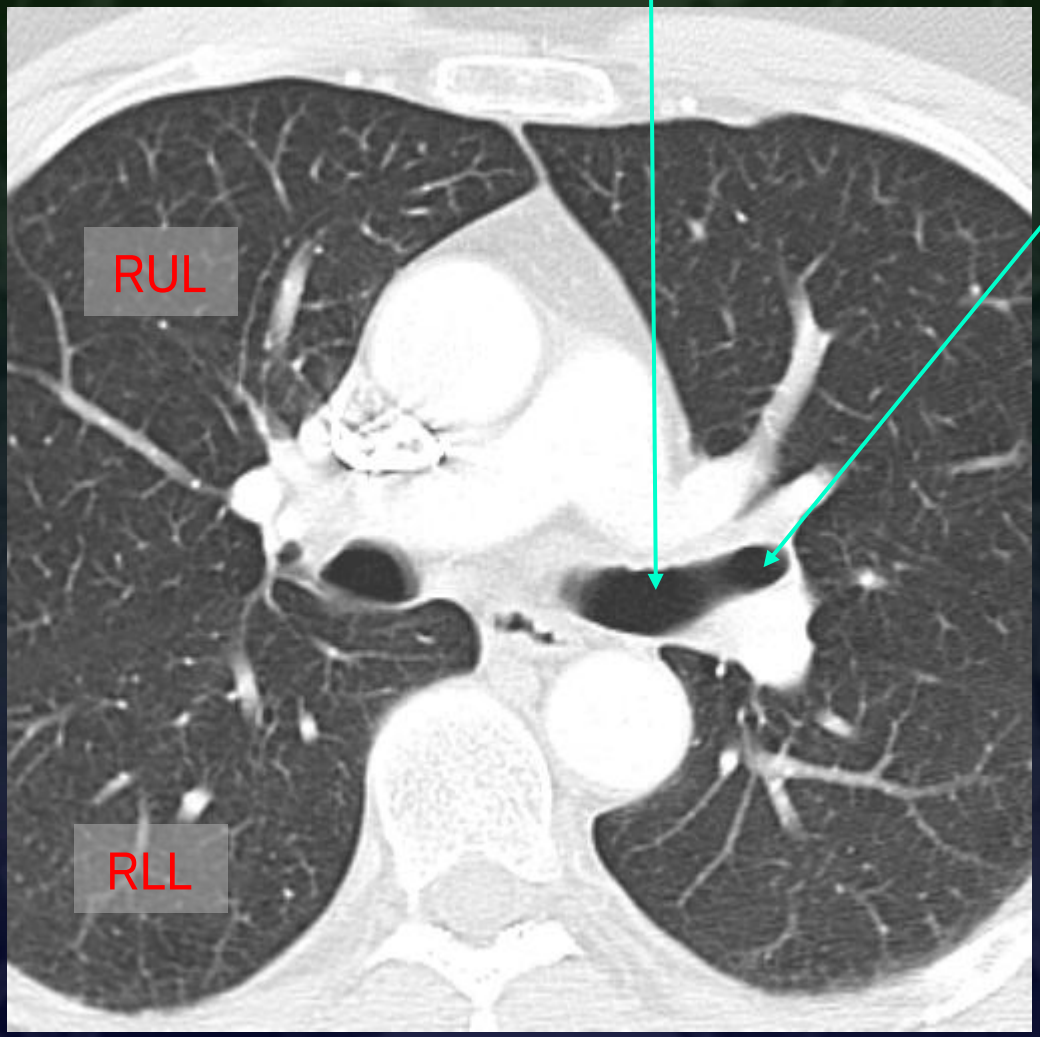
'--→ Bronchus intermedius (2nd pinch) -→ RML bronchus (heading ant)

-→ RLL bronchus (heading post)


RUL
LUL
RLL
anterior
anterior
apicoposterior

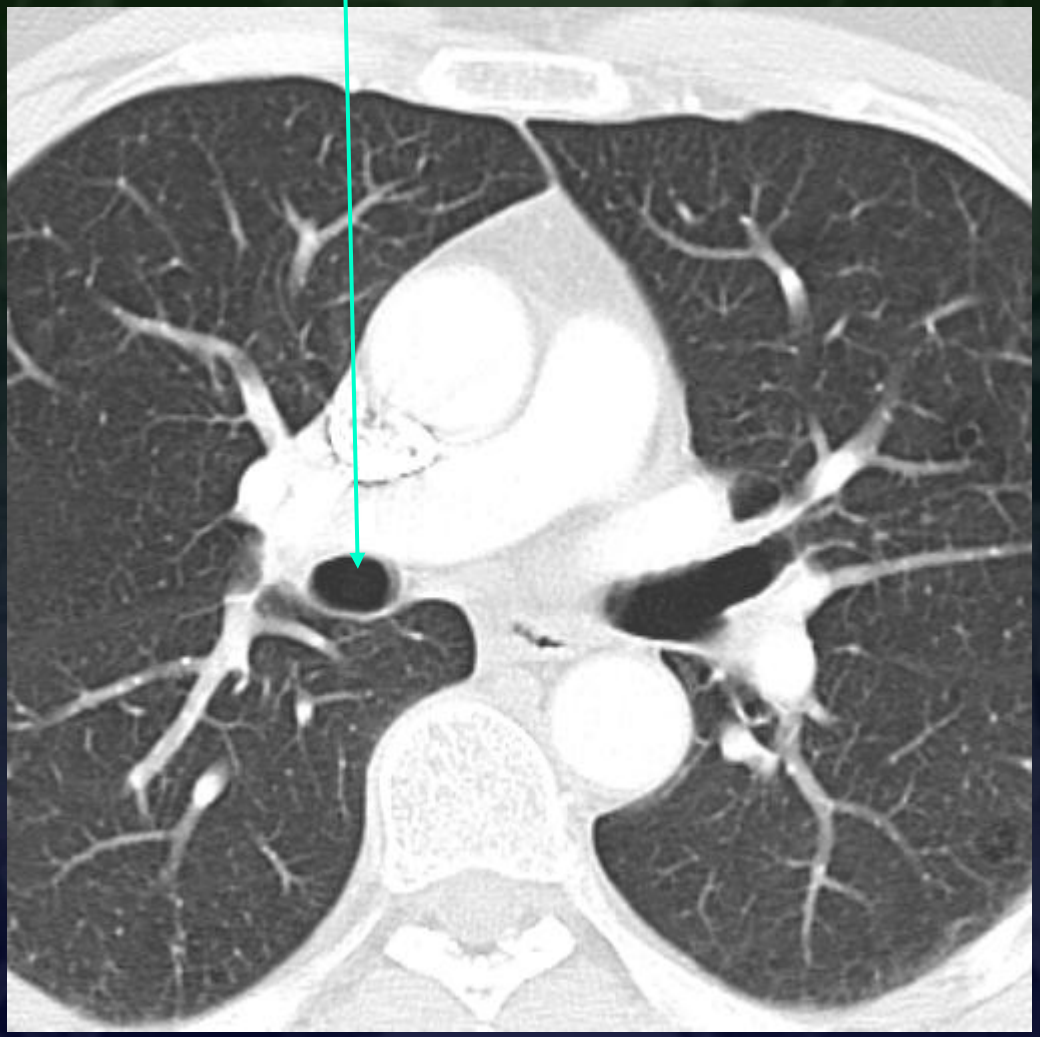


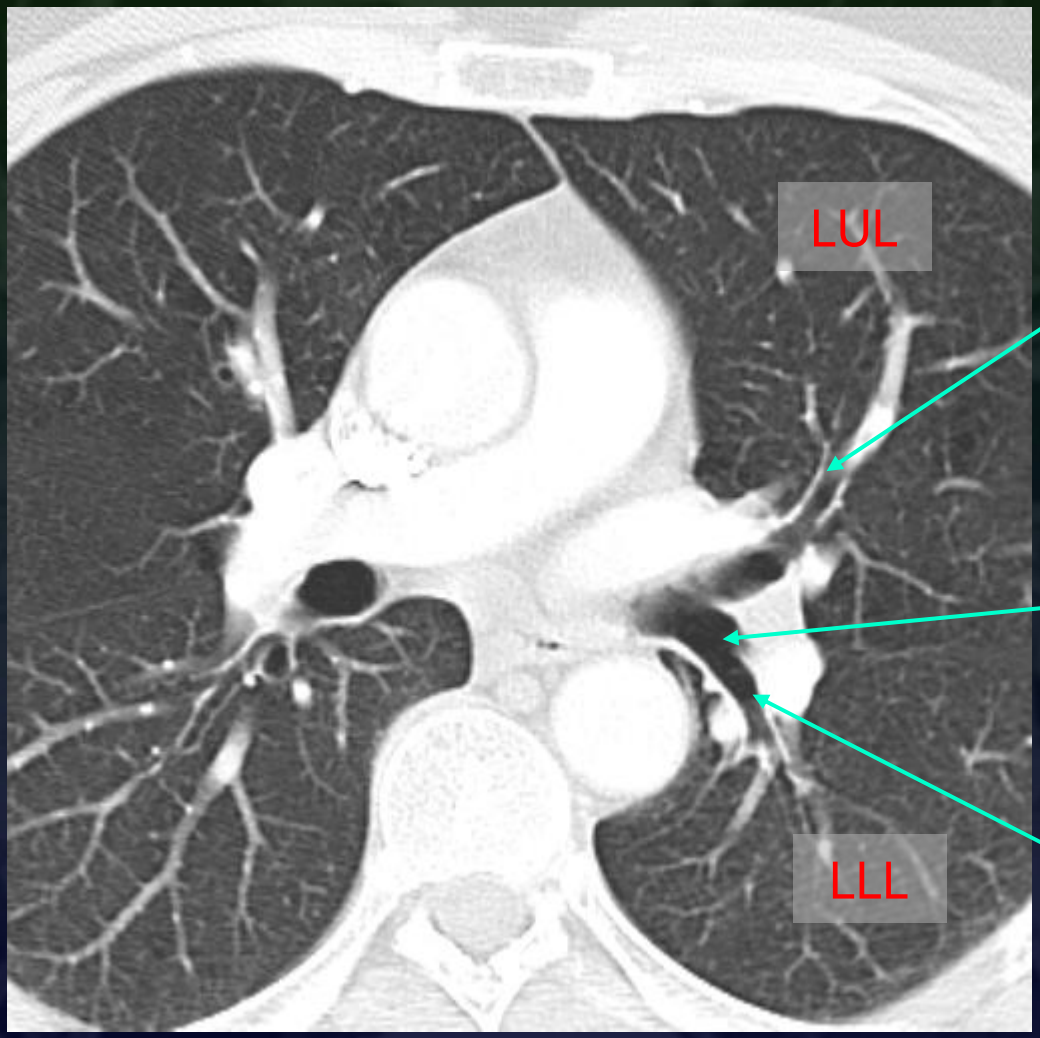

Bronchus Intermedius
LUL Bronchus
LUL



Lt main bronchus -→ (1st pinch) --→ LUL bronchus (heading upward)
--→ Lingular segmental bronchus (heading ant)
--→ LLL bronchus (heading post)

Bronchus Intermedius



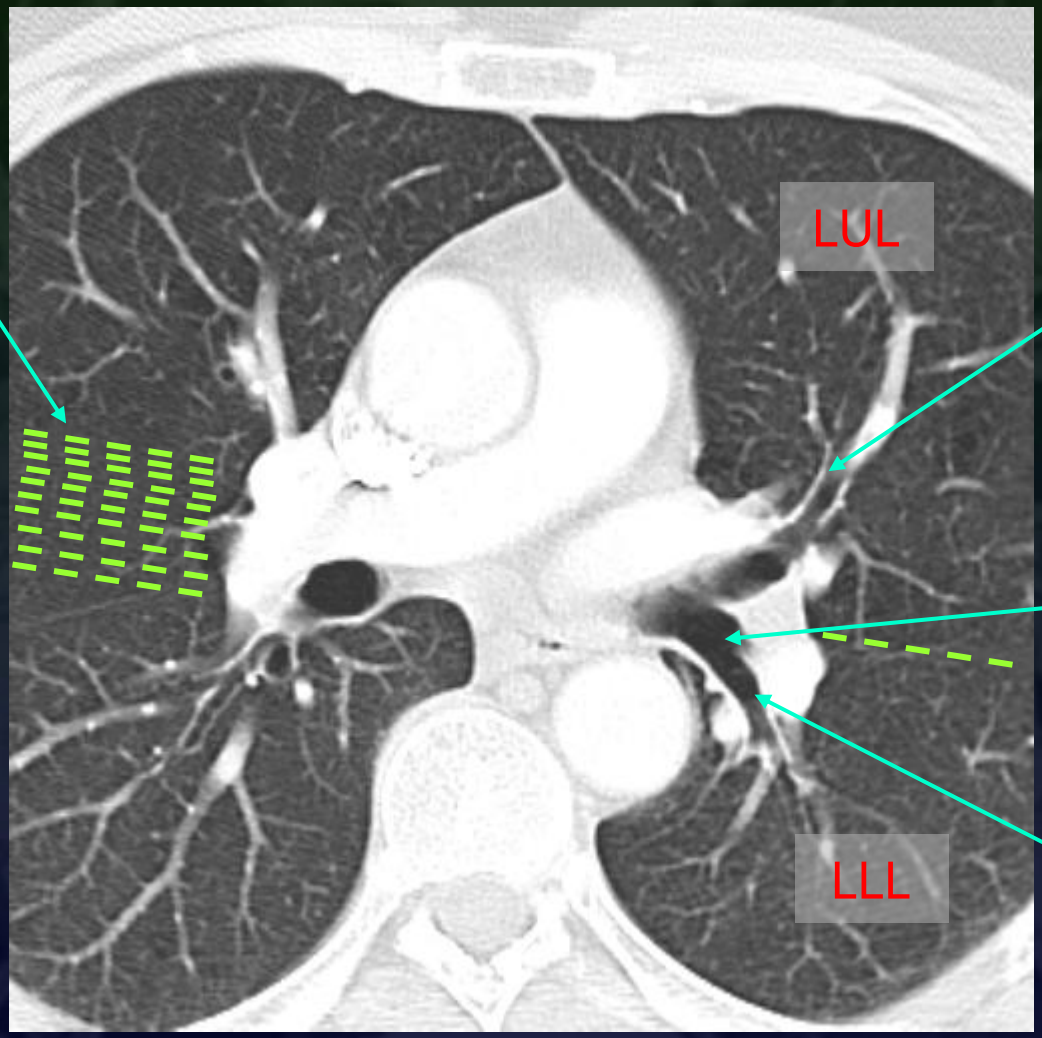


lingular segment LUL

LLL bronchus

superior segment LLL

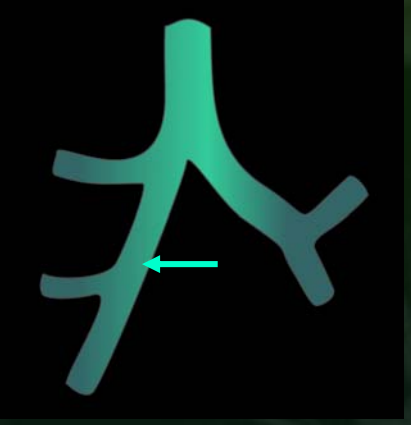
Horizontal Fissure

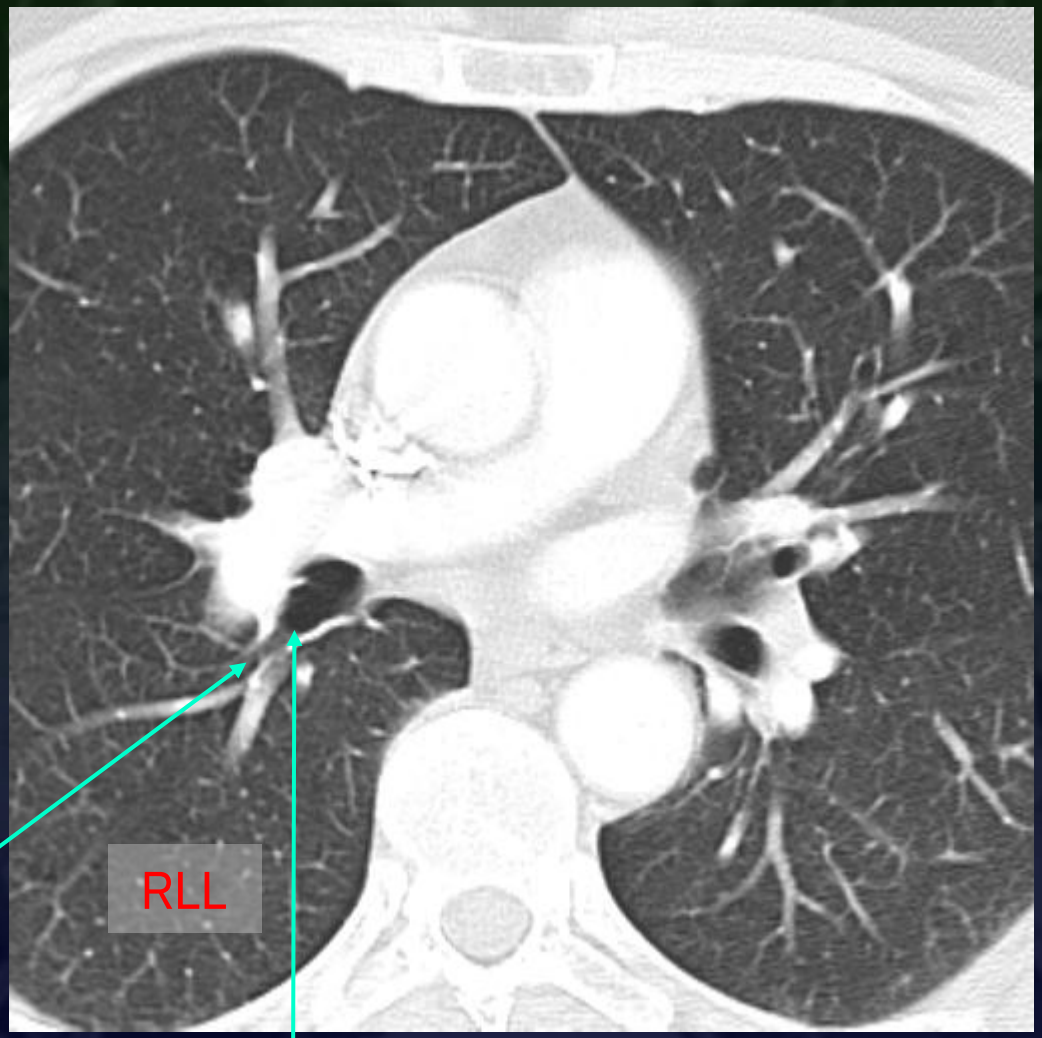


lingular segment LUL

LLL bronchus

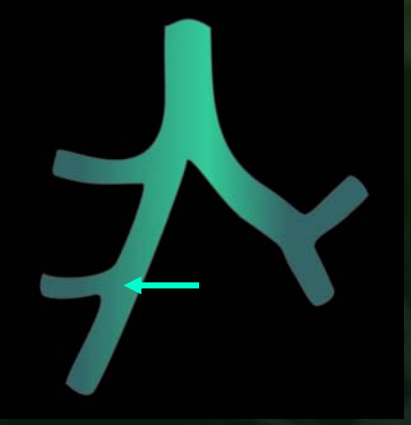
superior segment LLL



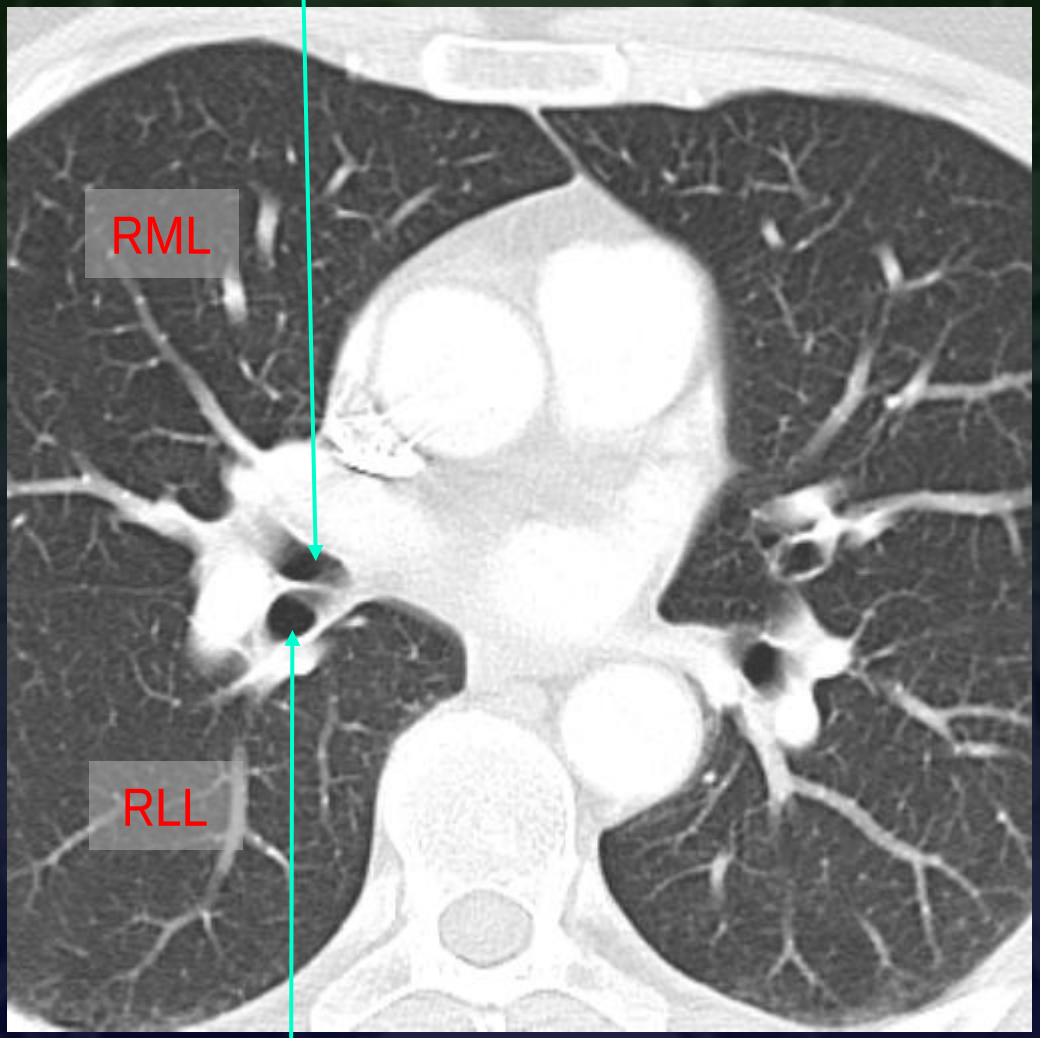


RLL:
Superior
segment

Right Lower Lobe Bronchus



Right Middle Lobe Bronchus



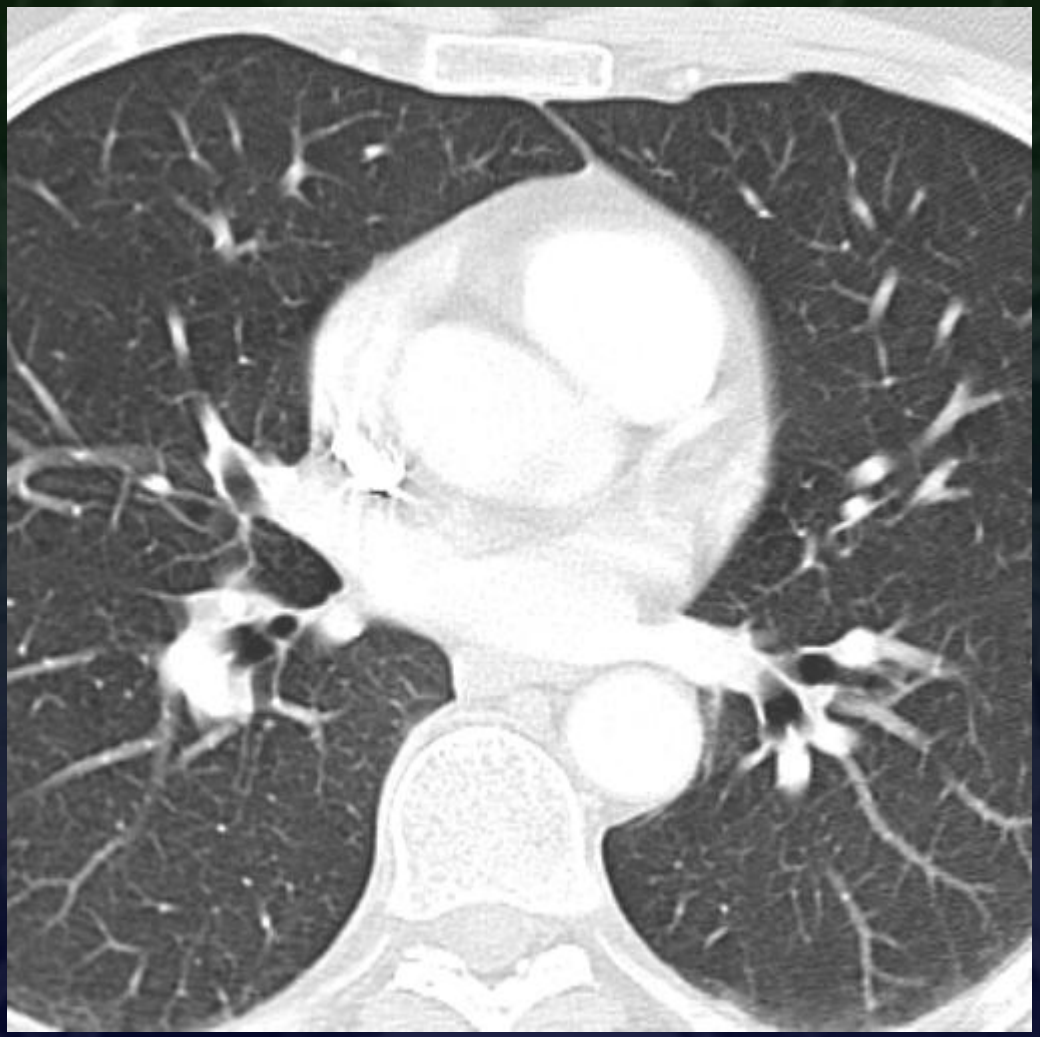
Right Lower Lobe Bronchus

Right Middle Lobe Segments x 2

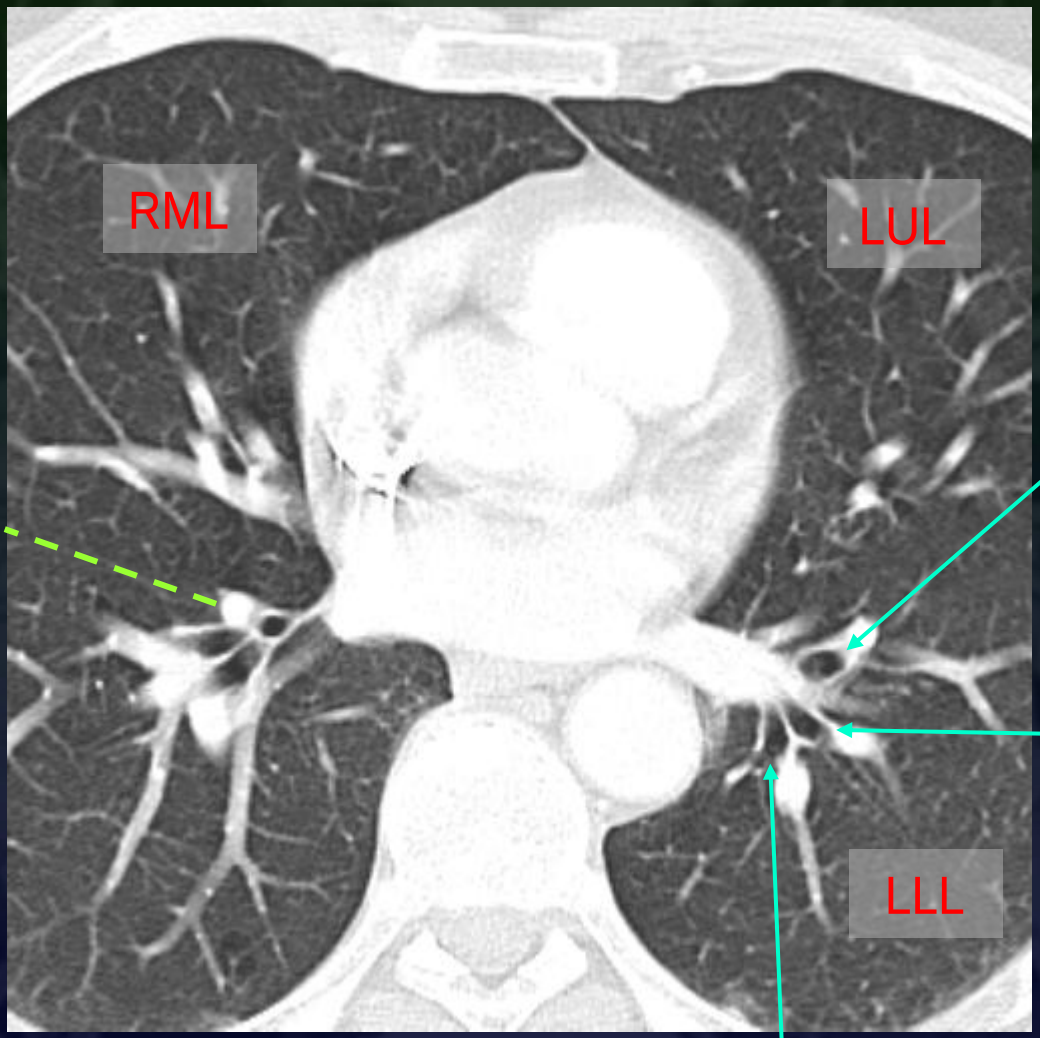
medial

2

lateral



Left Lower Lobe: Basal Segments x 3



anteromedial basal

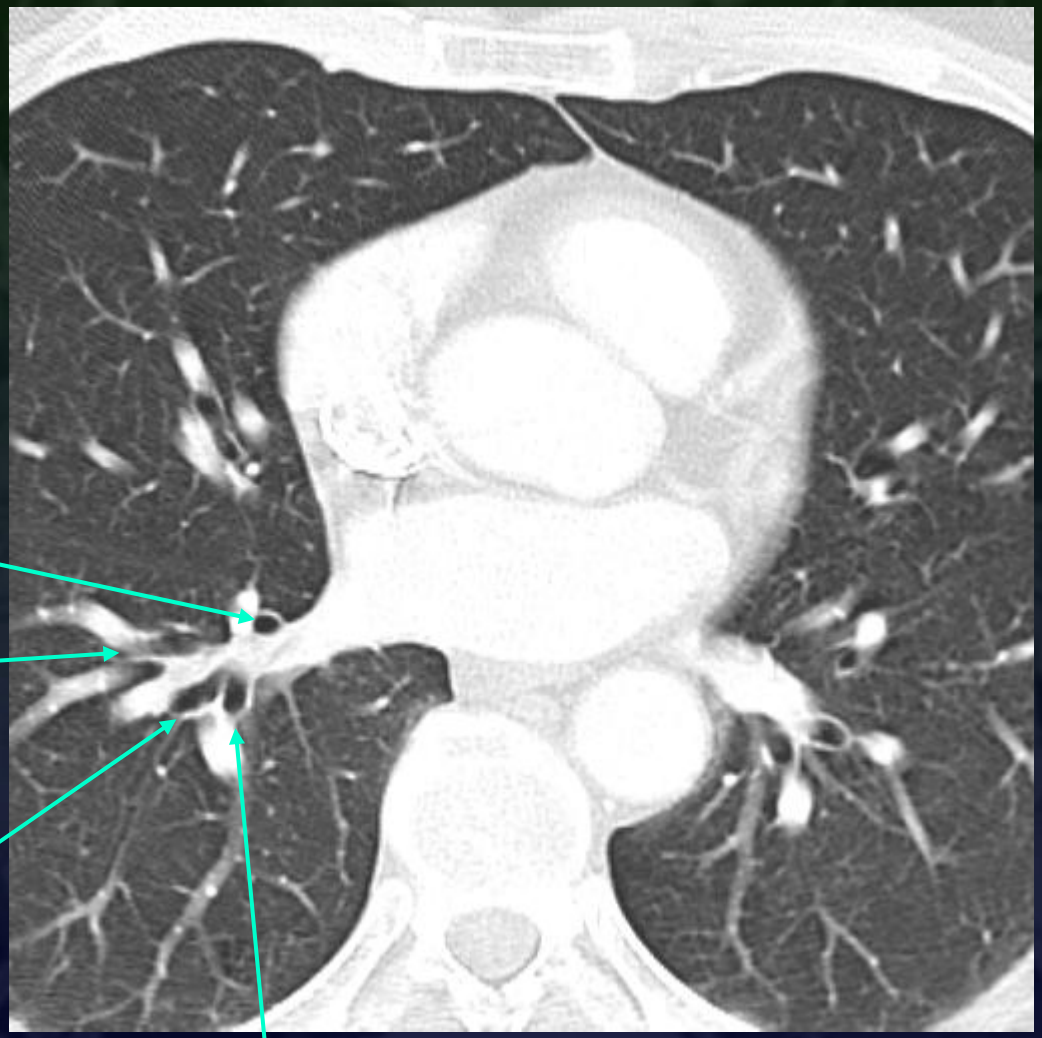
lat basal

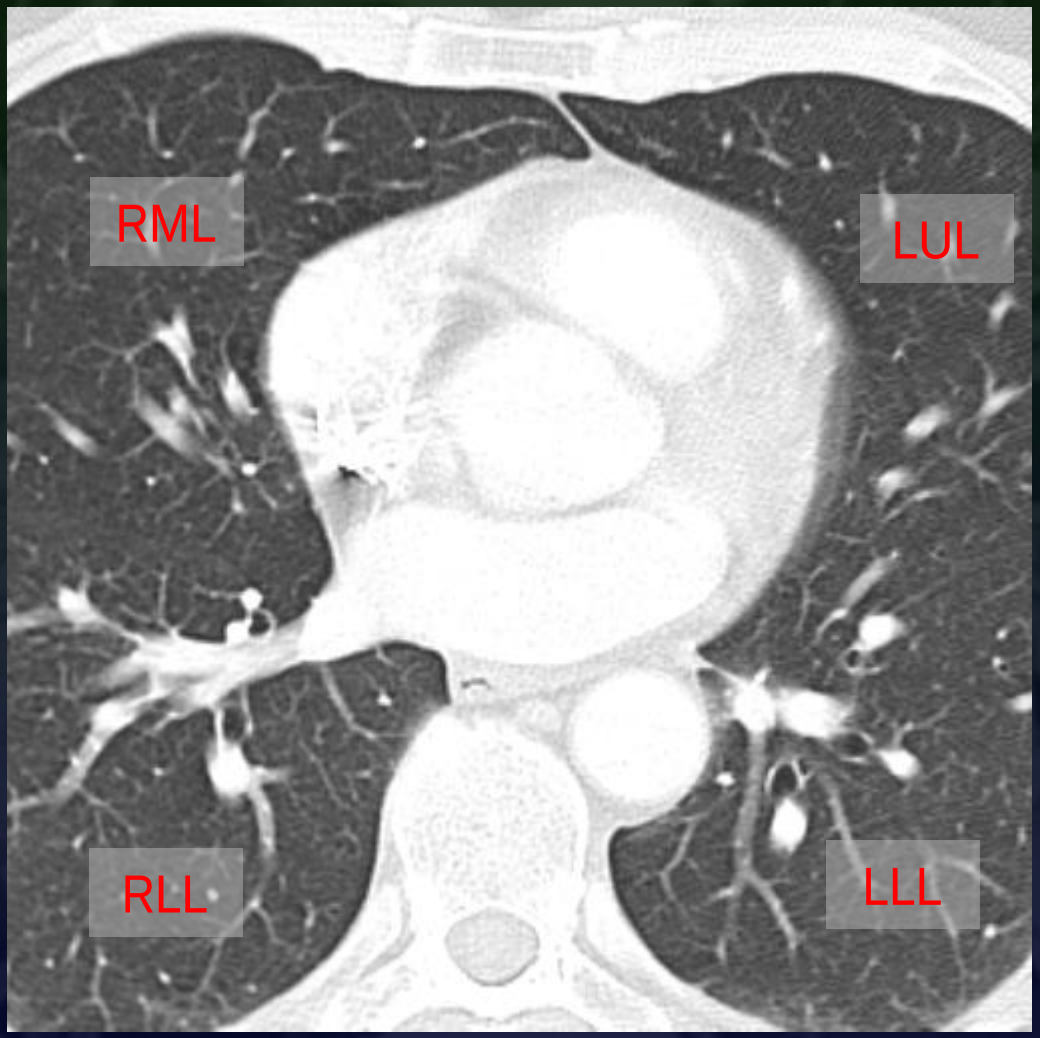
post basal

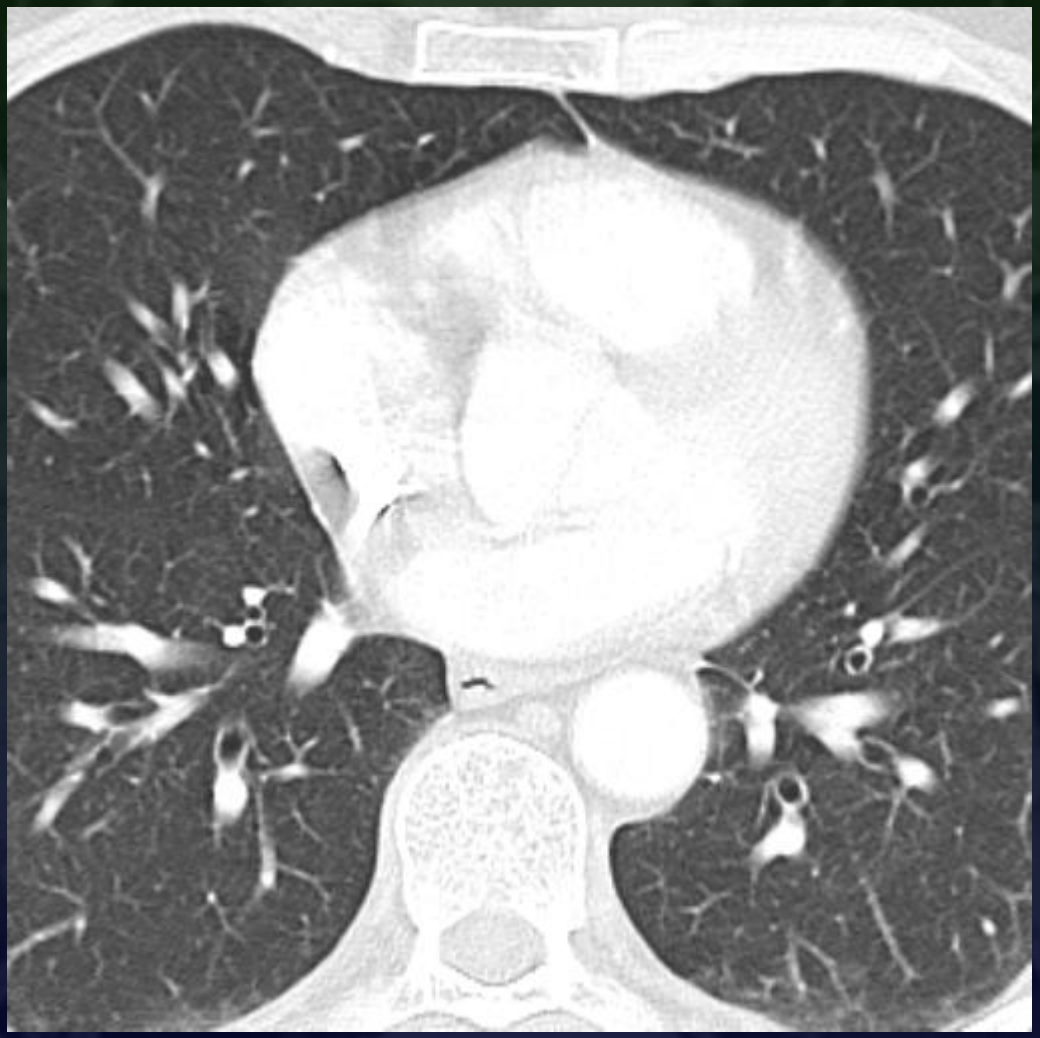
3

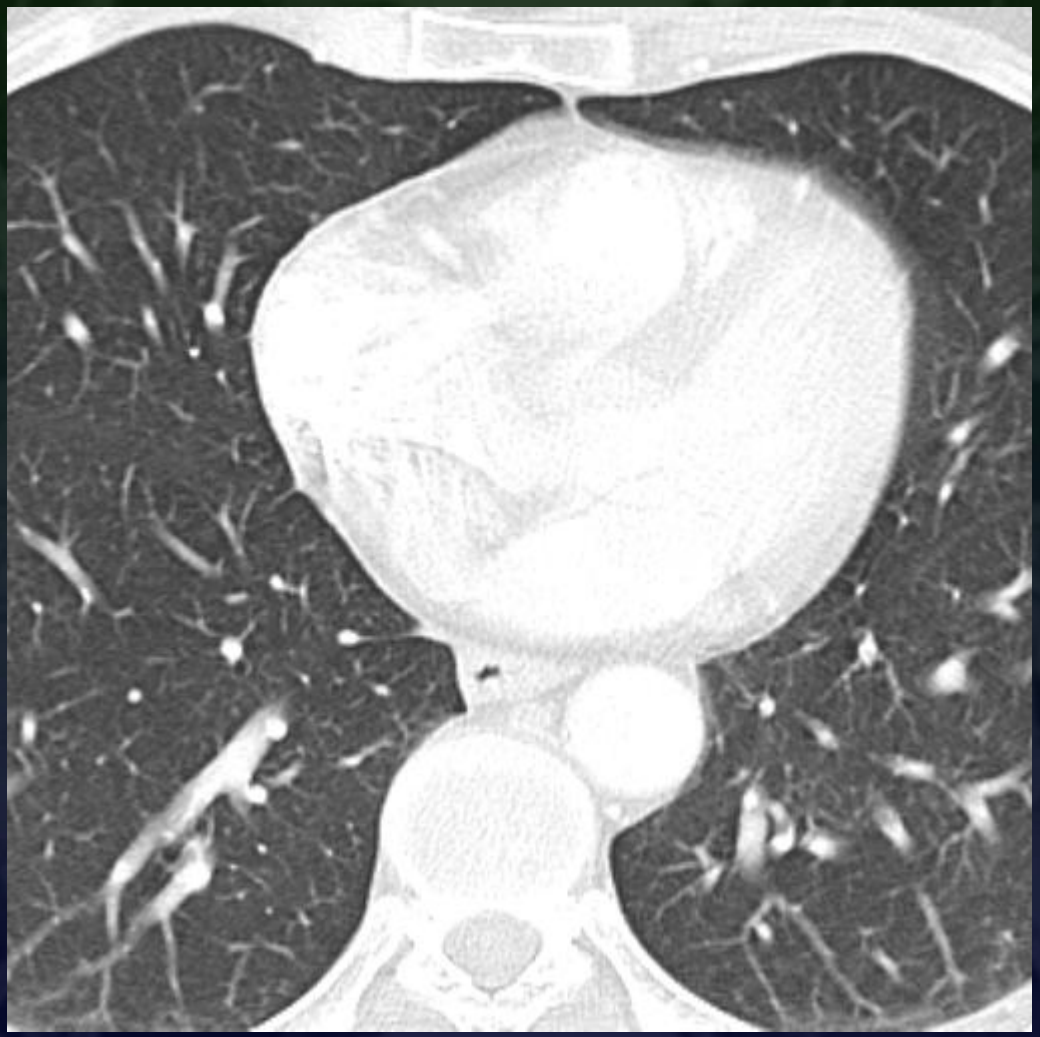
Right Lower Lobe: Basal Segments x 4

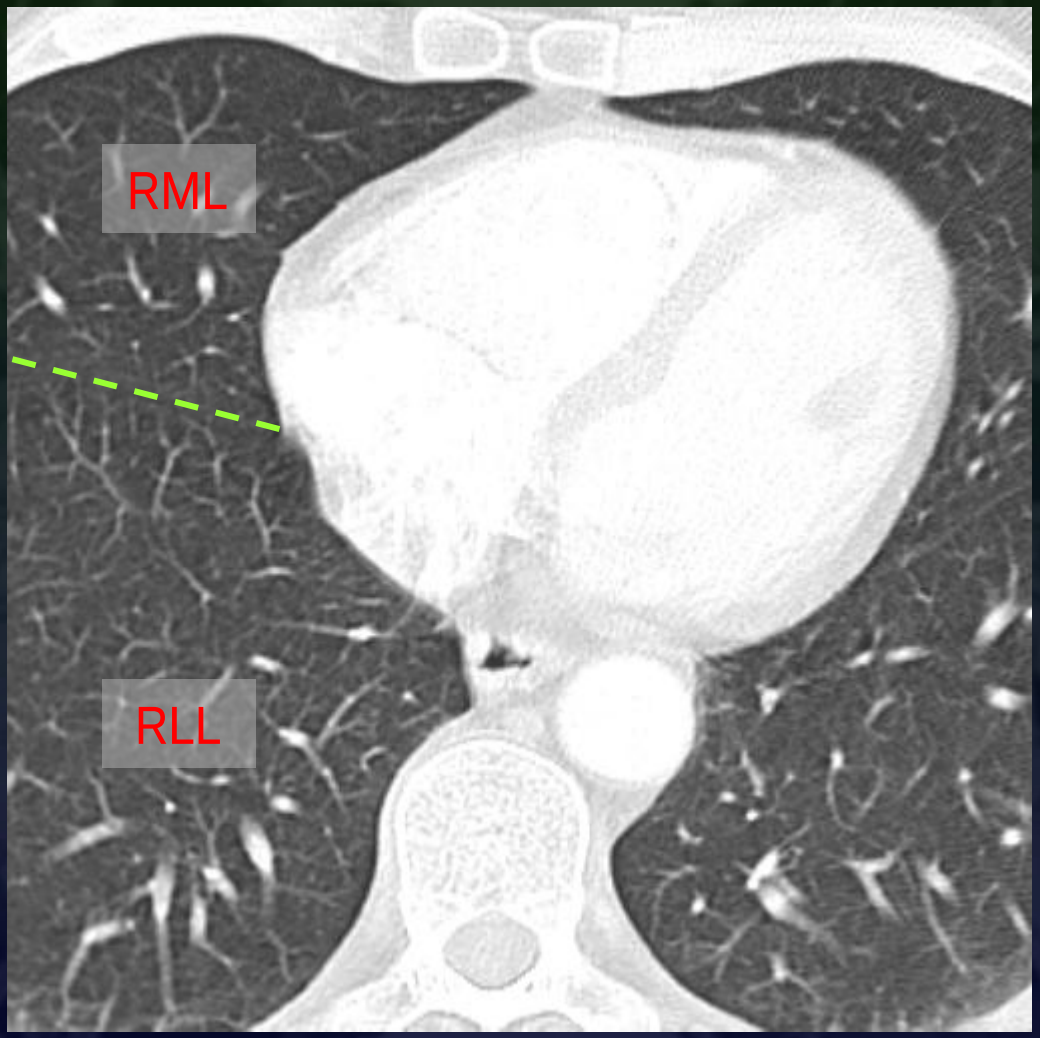
4

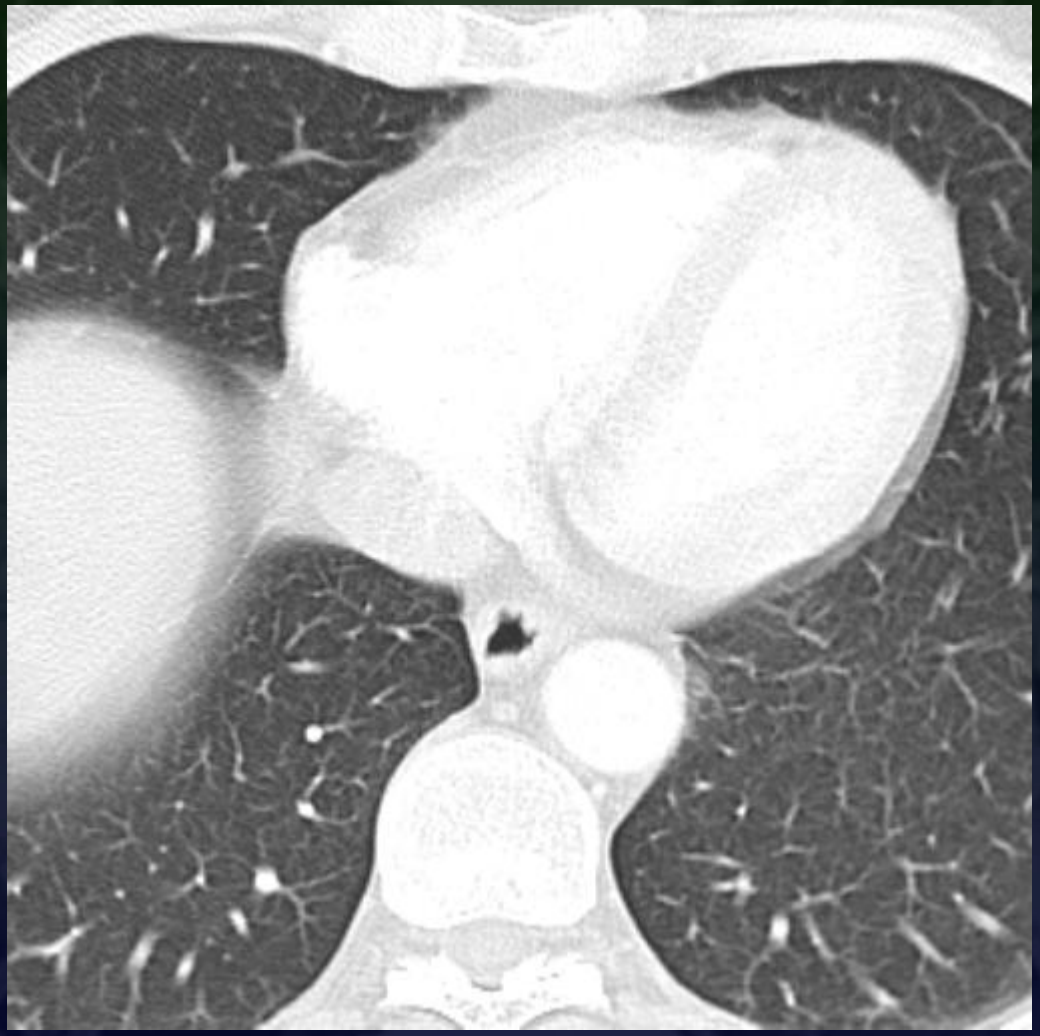


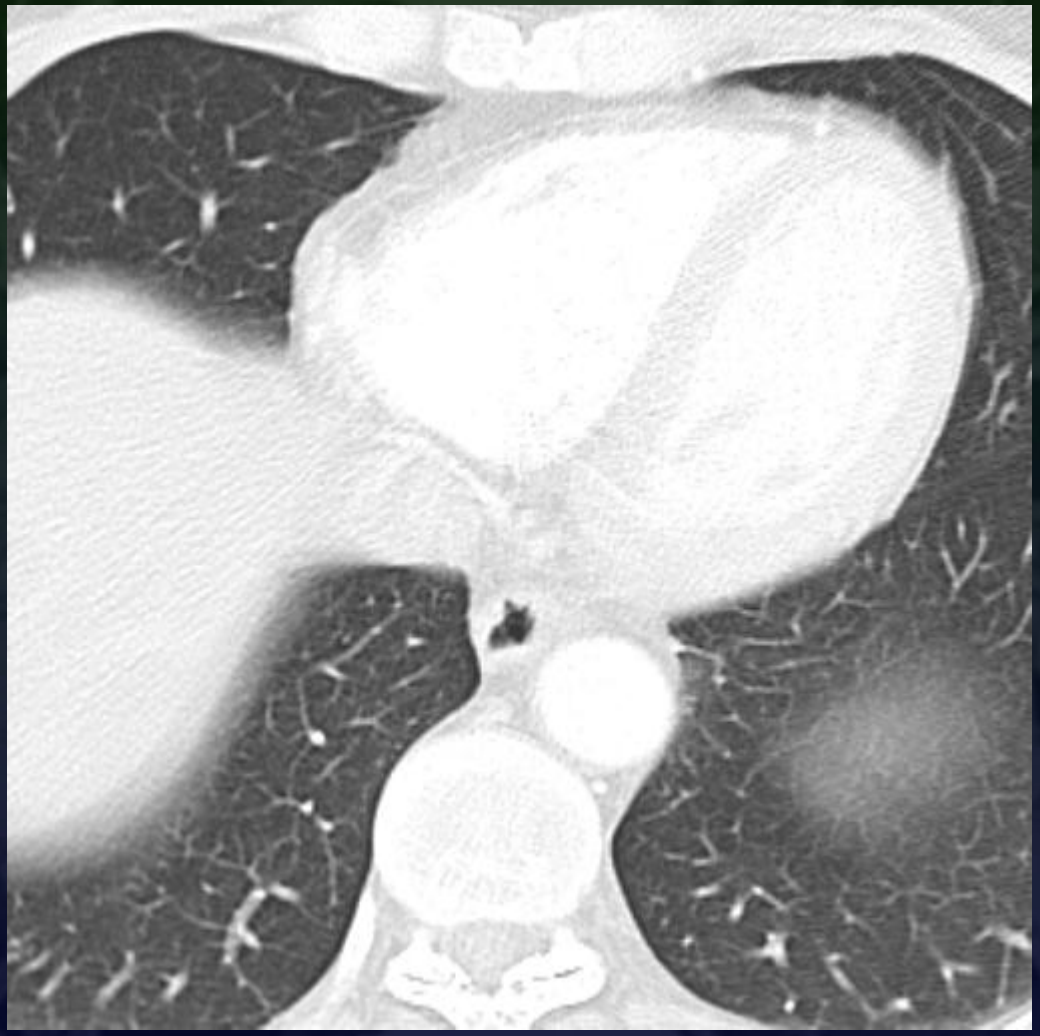

RML
LUL
RLL
LLL



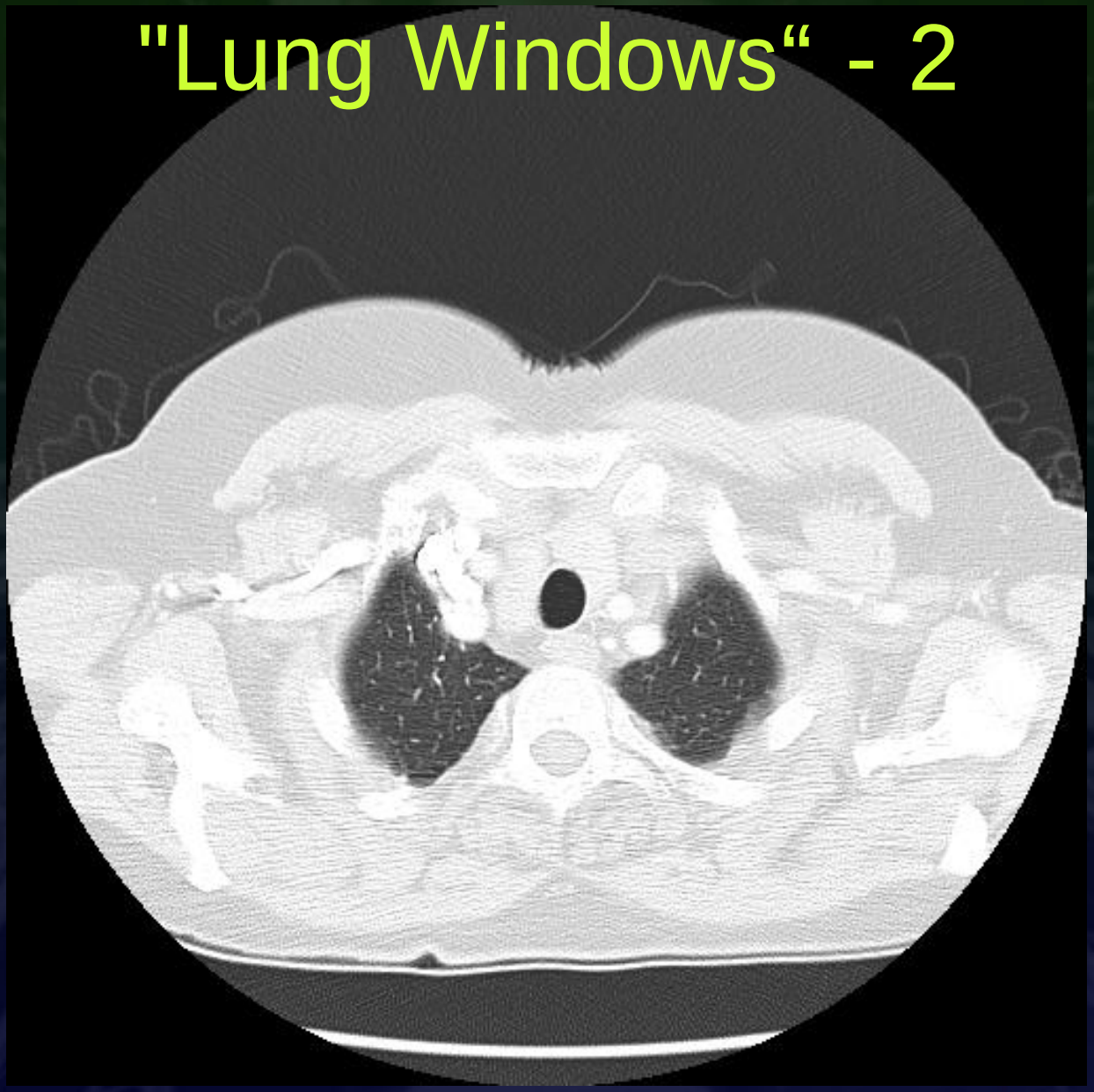


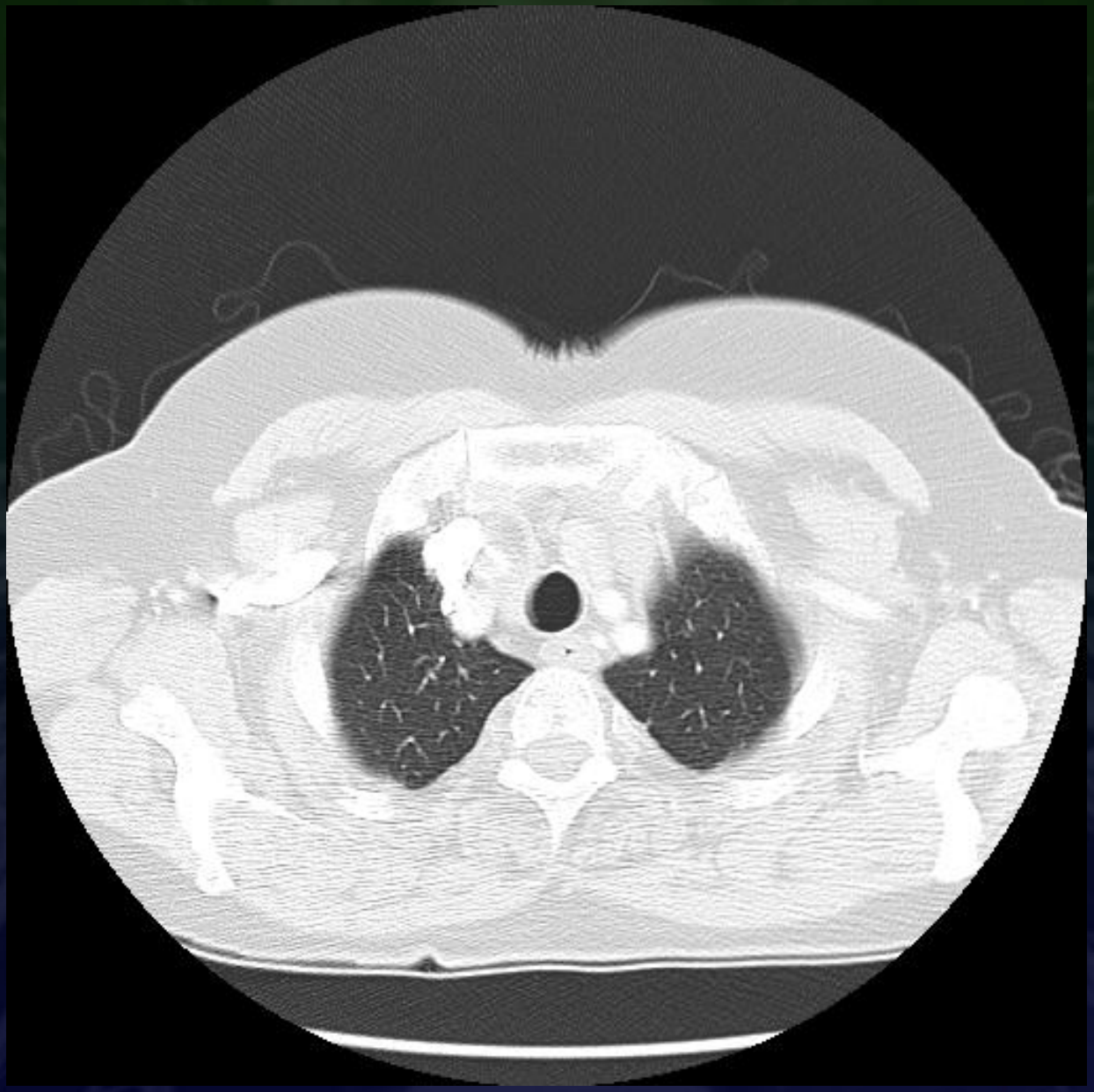

RML
RLL

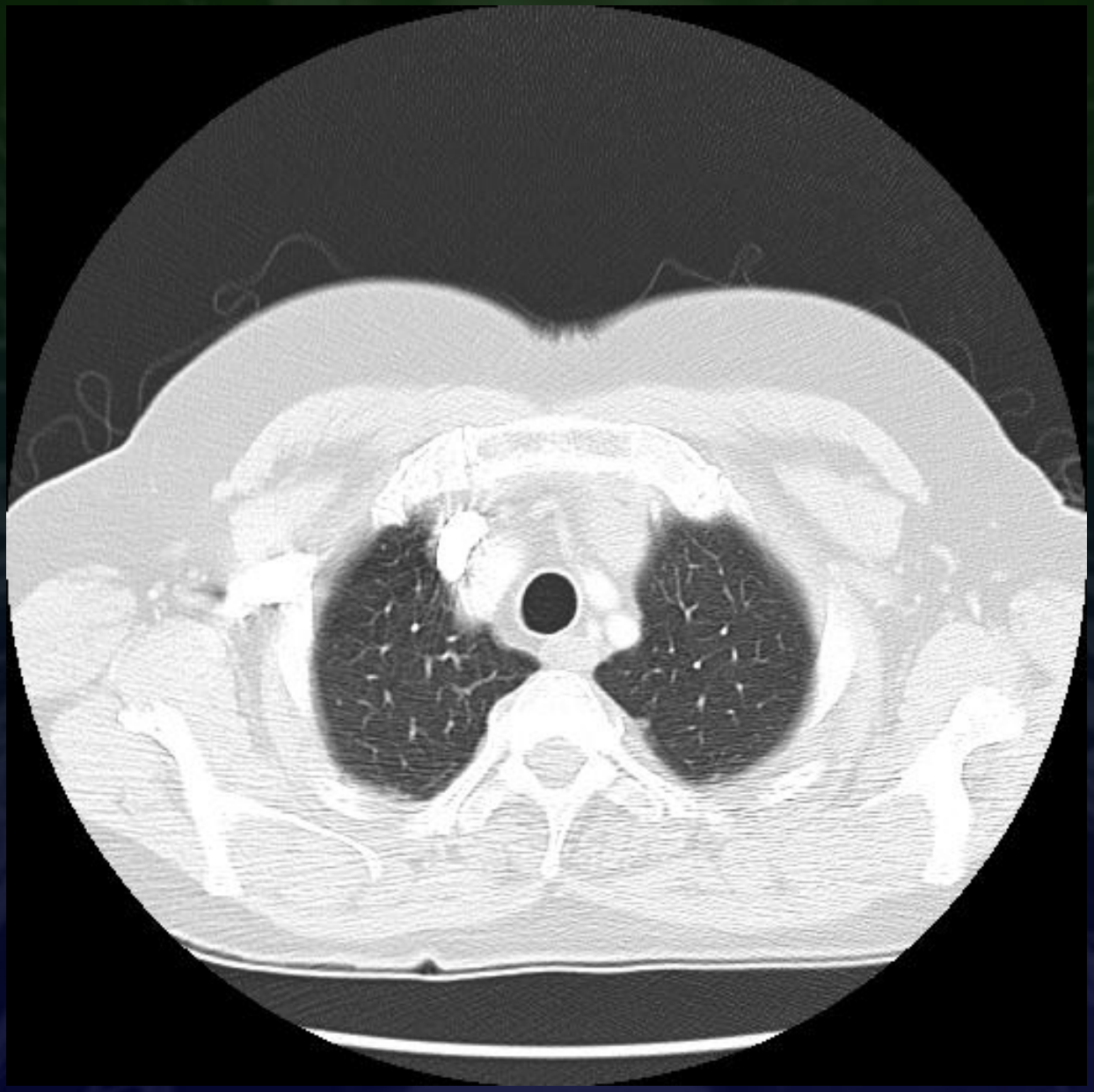


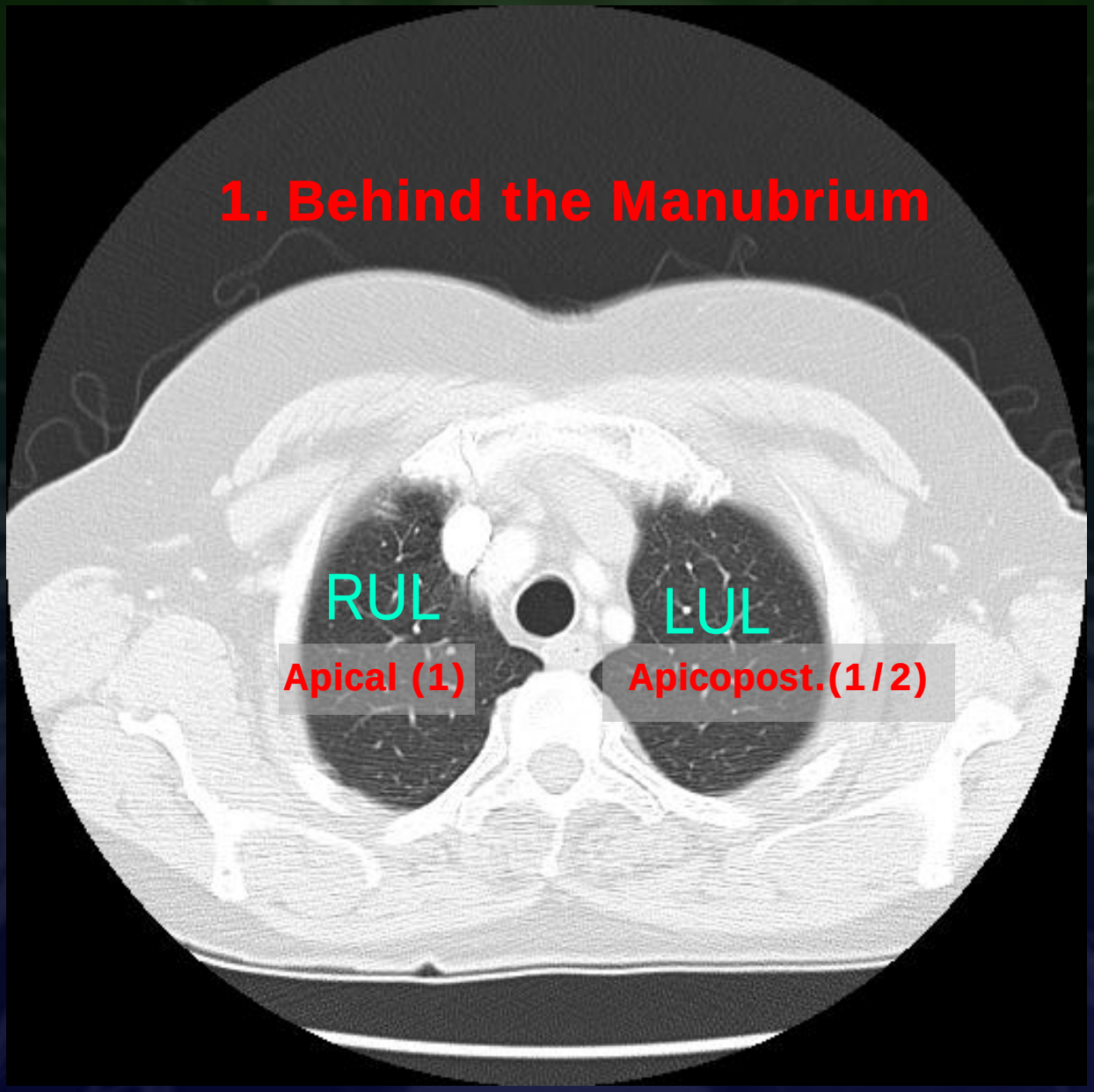


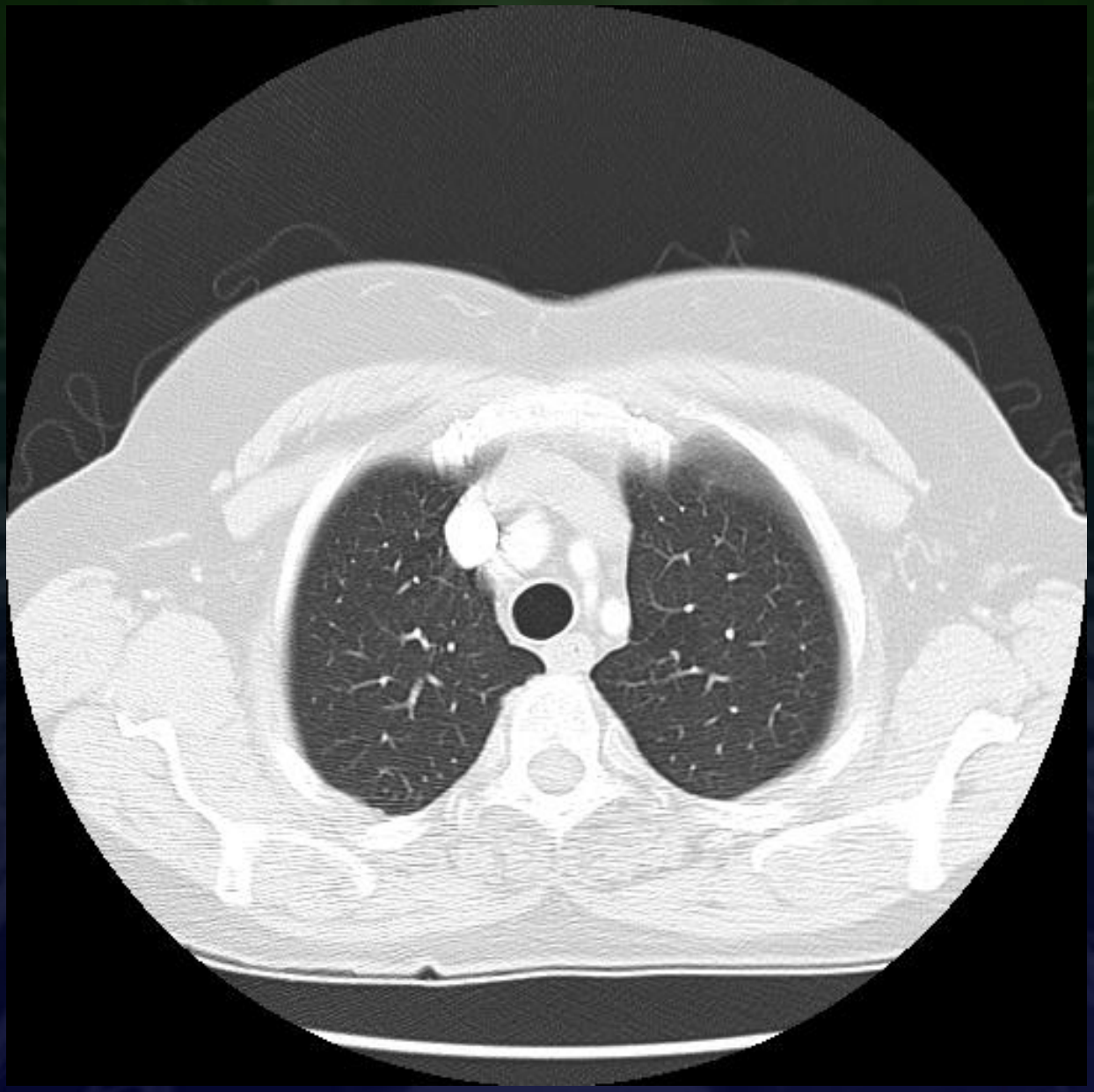
"Lung Windows“ - 2

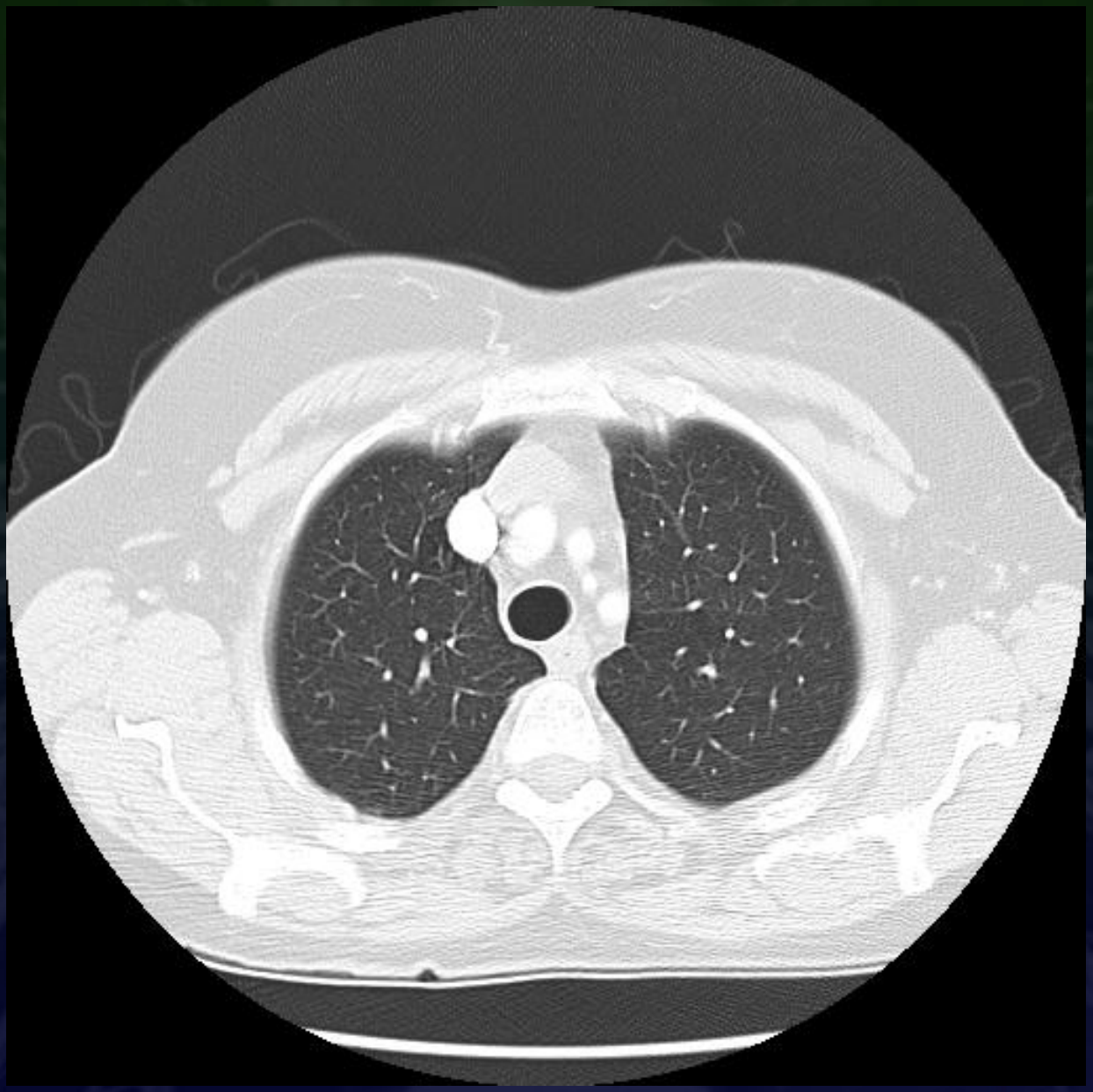


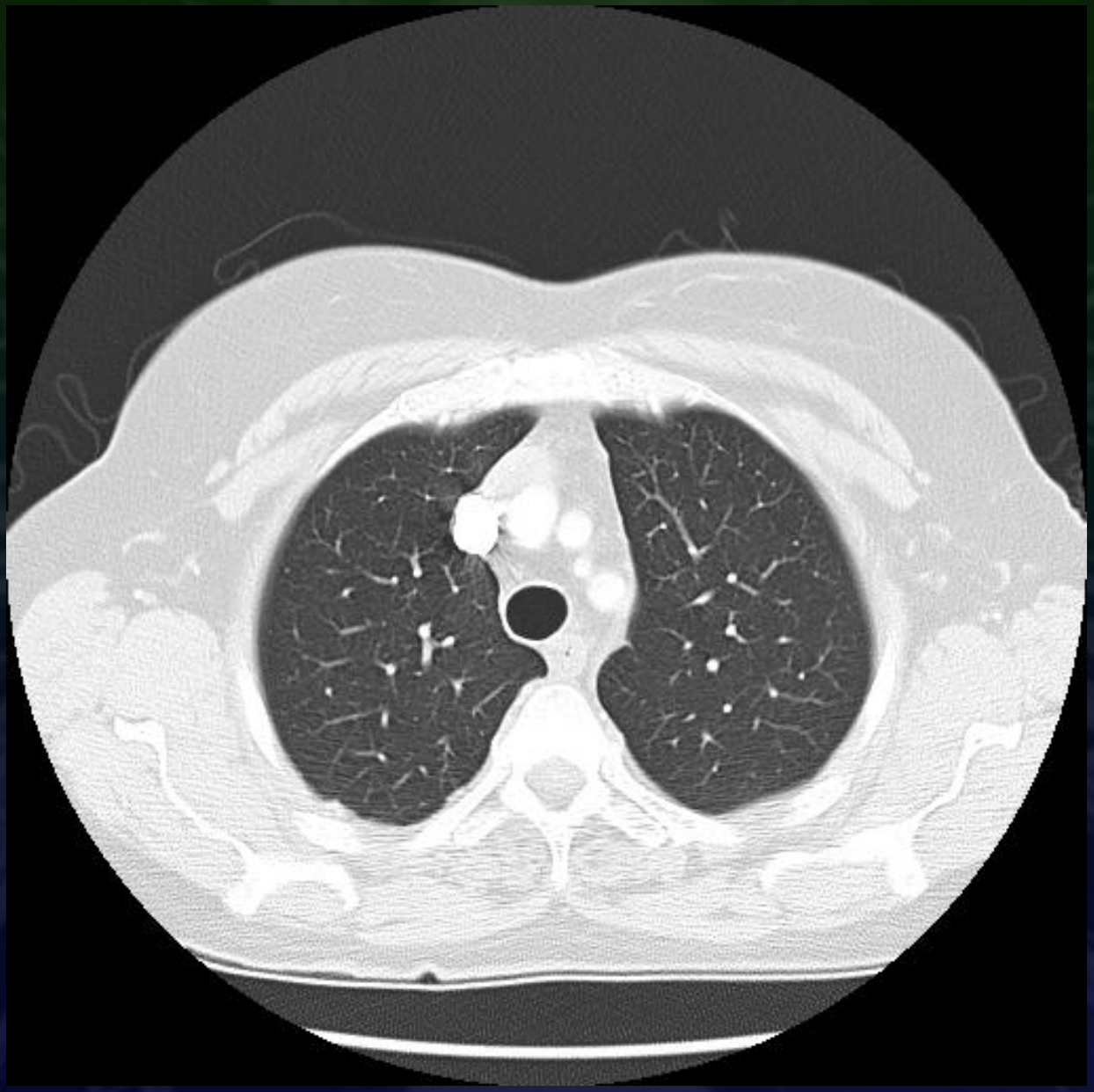


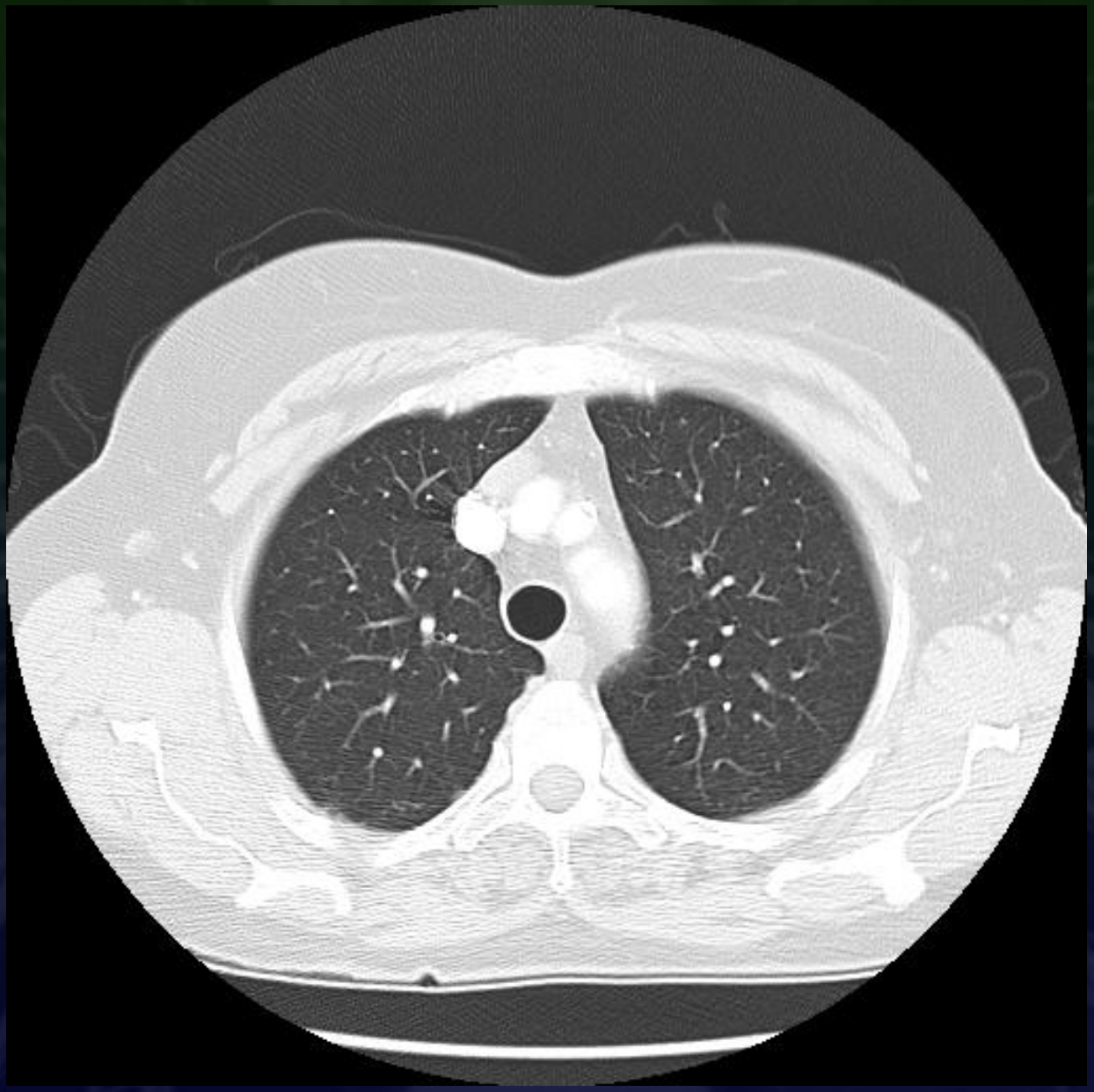


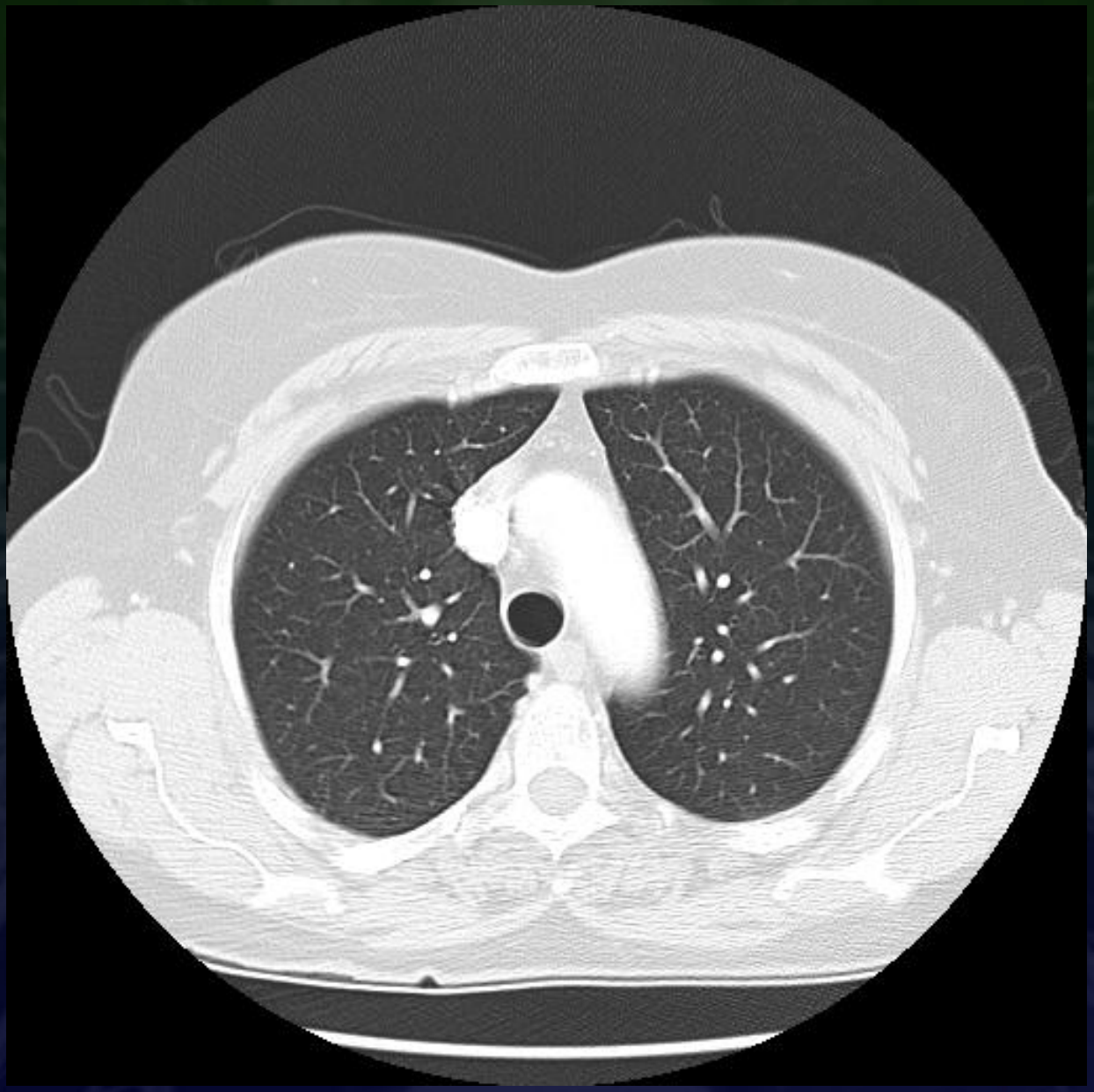

1. Behind the Manubrium
RUL
Apical (1)
LUL
Apicopost.(1/2)

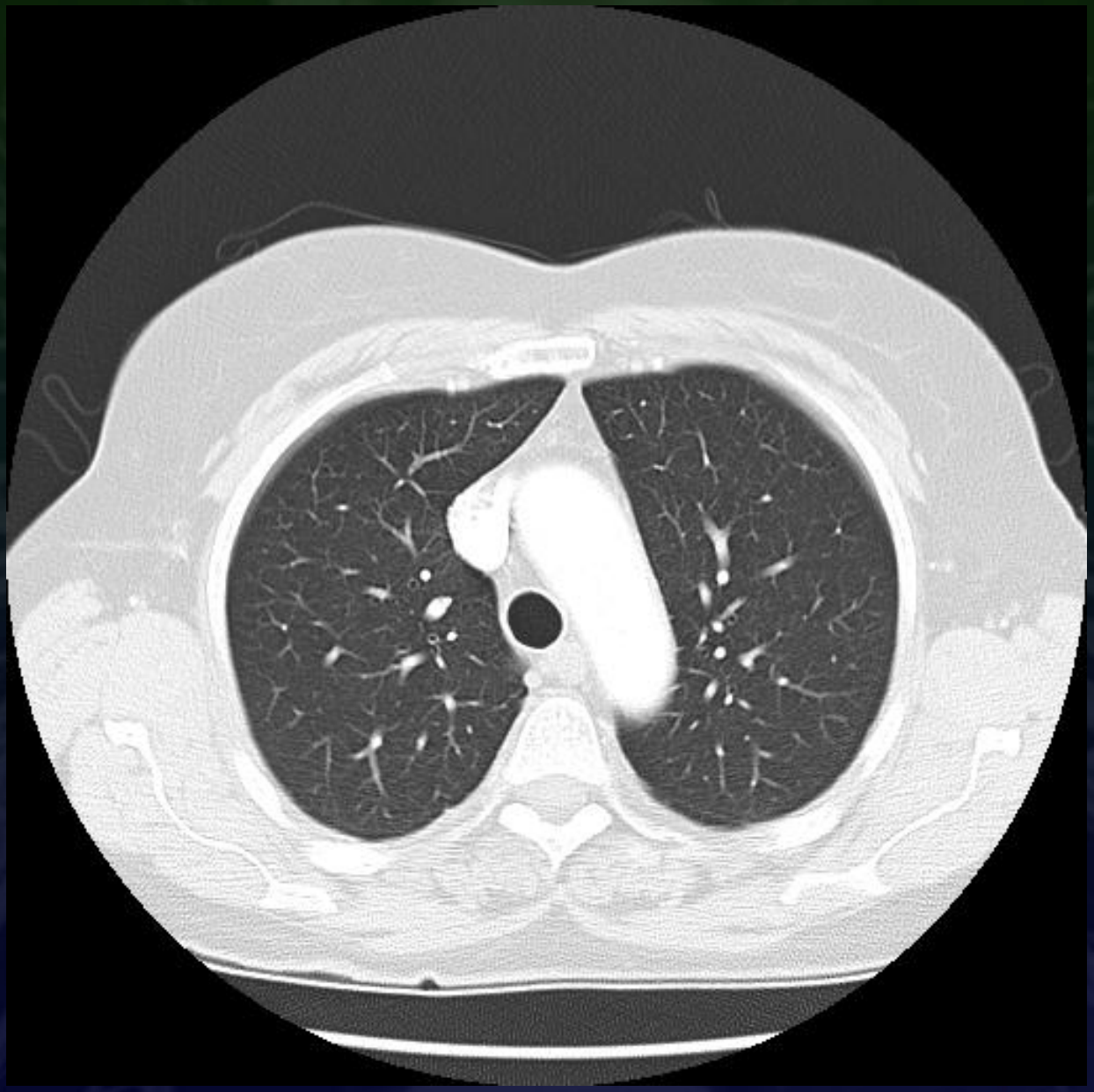


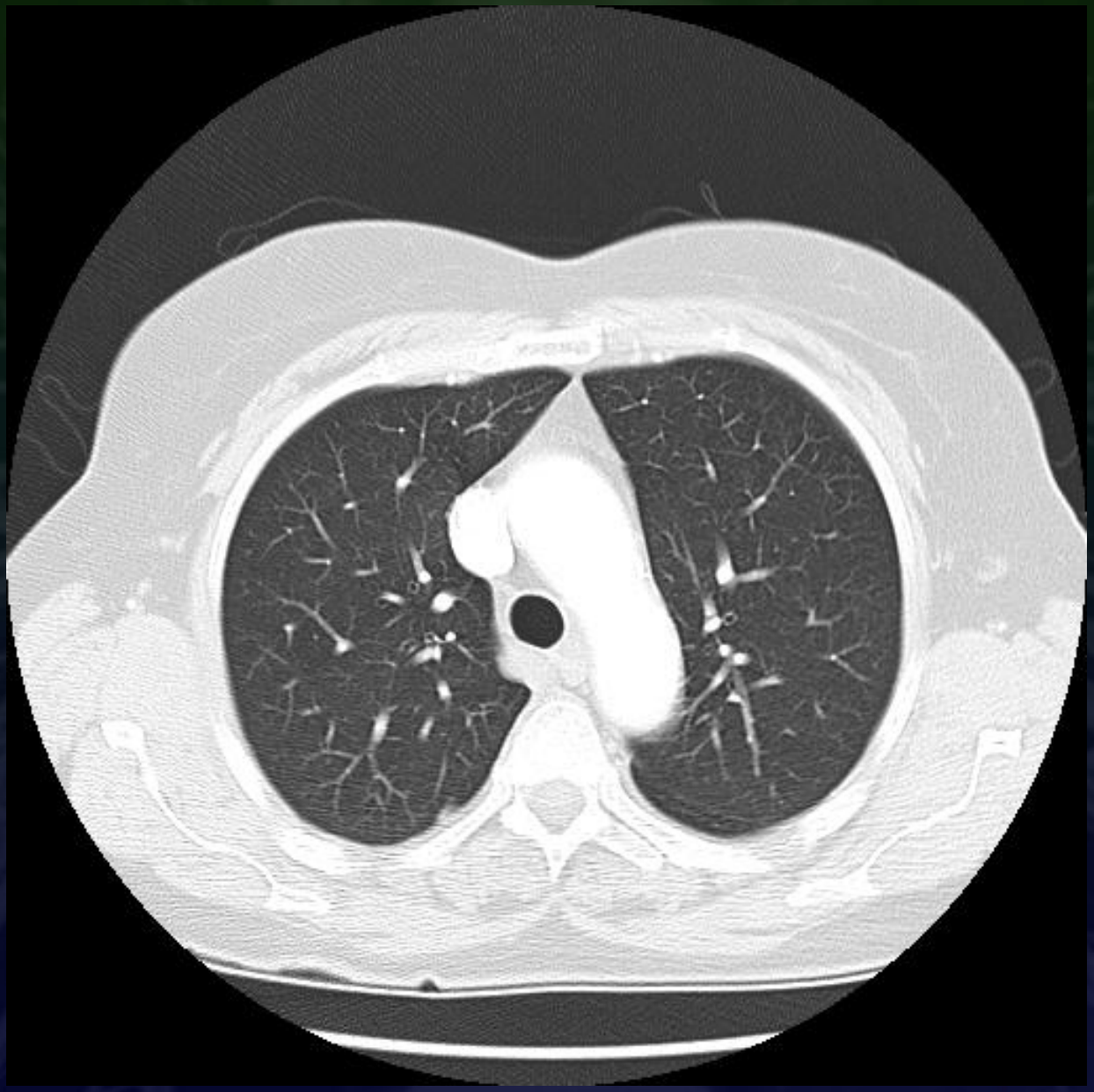




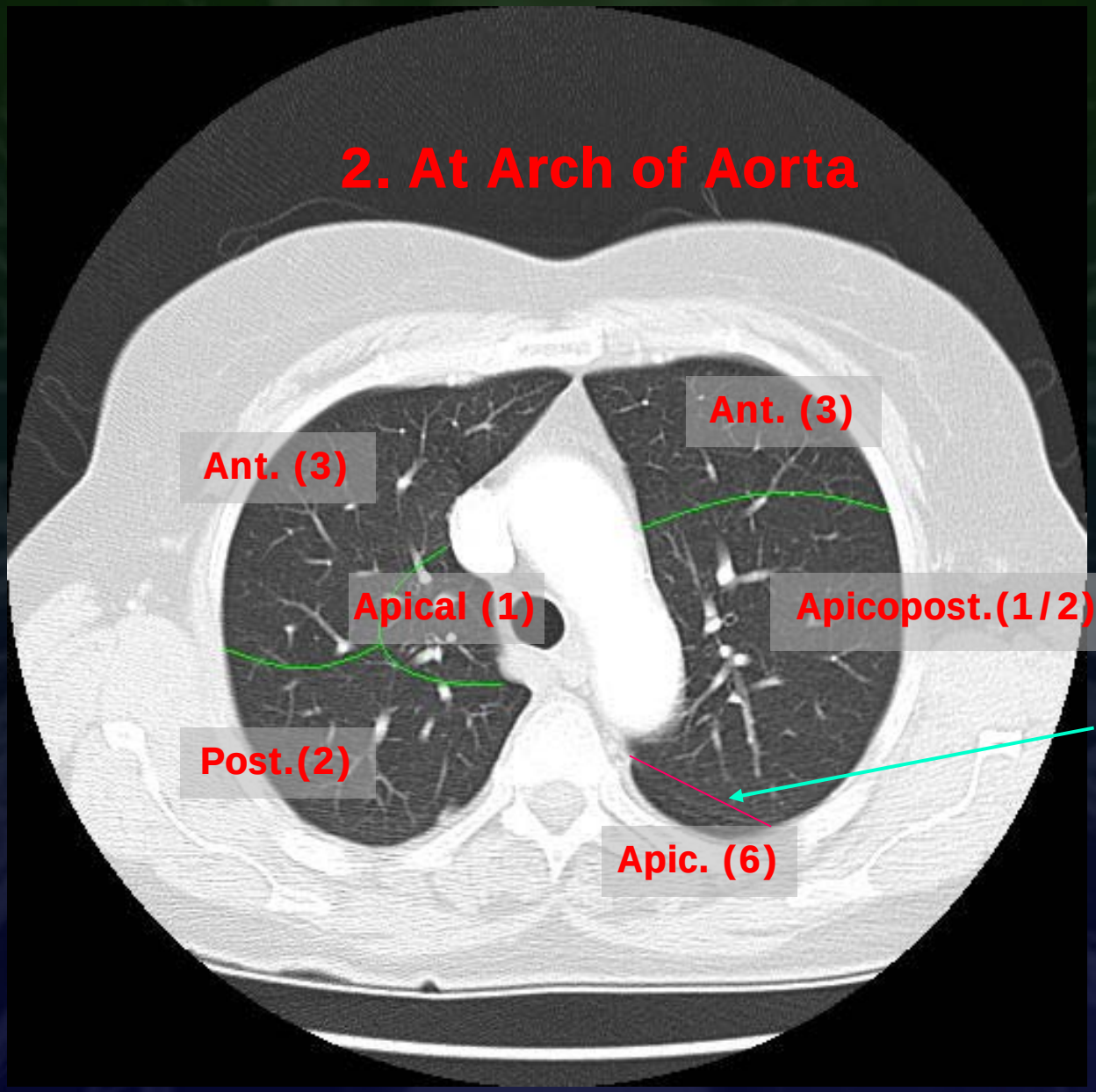




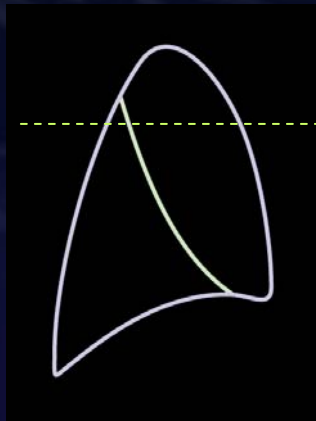


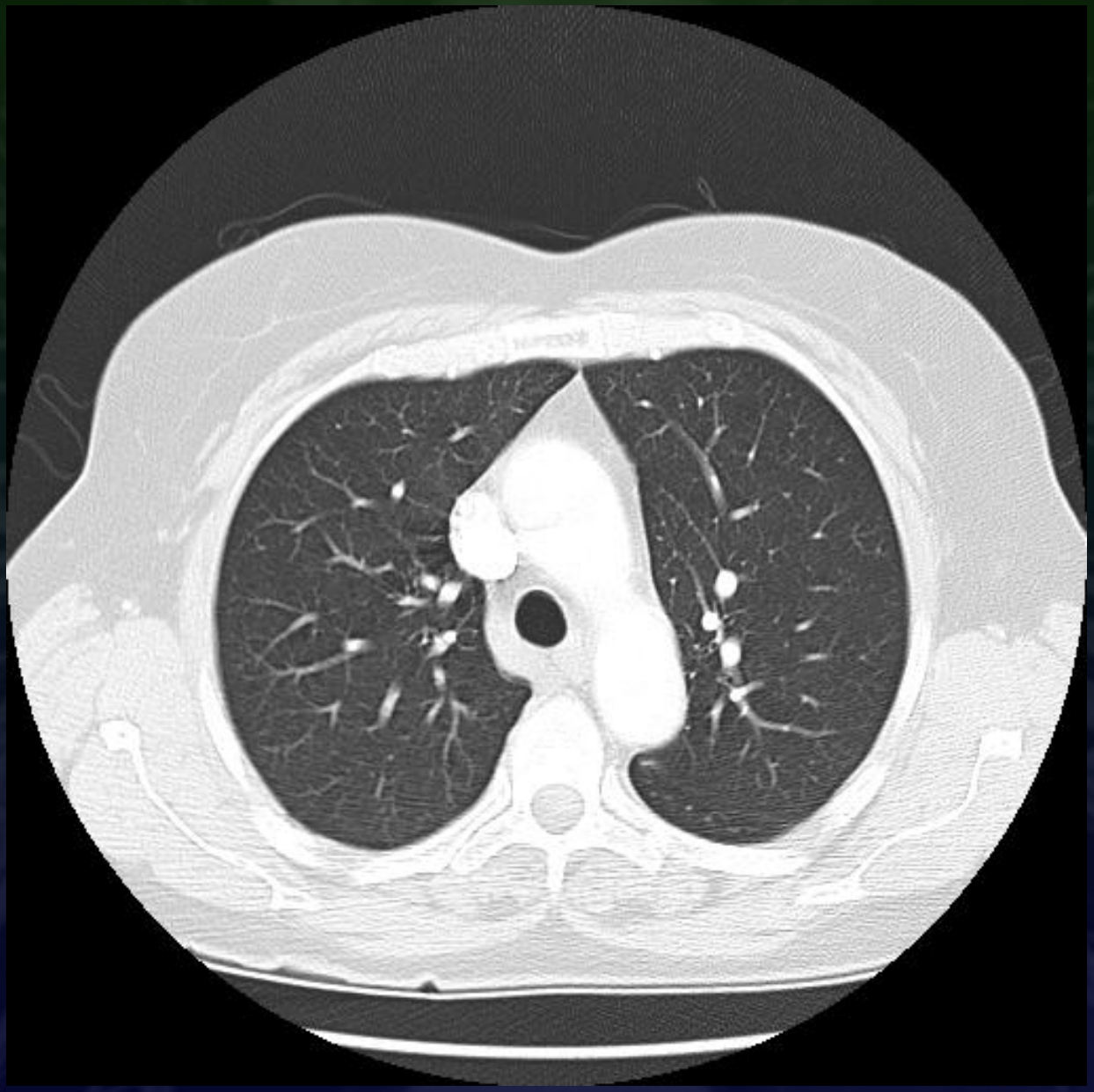


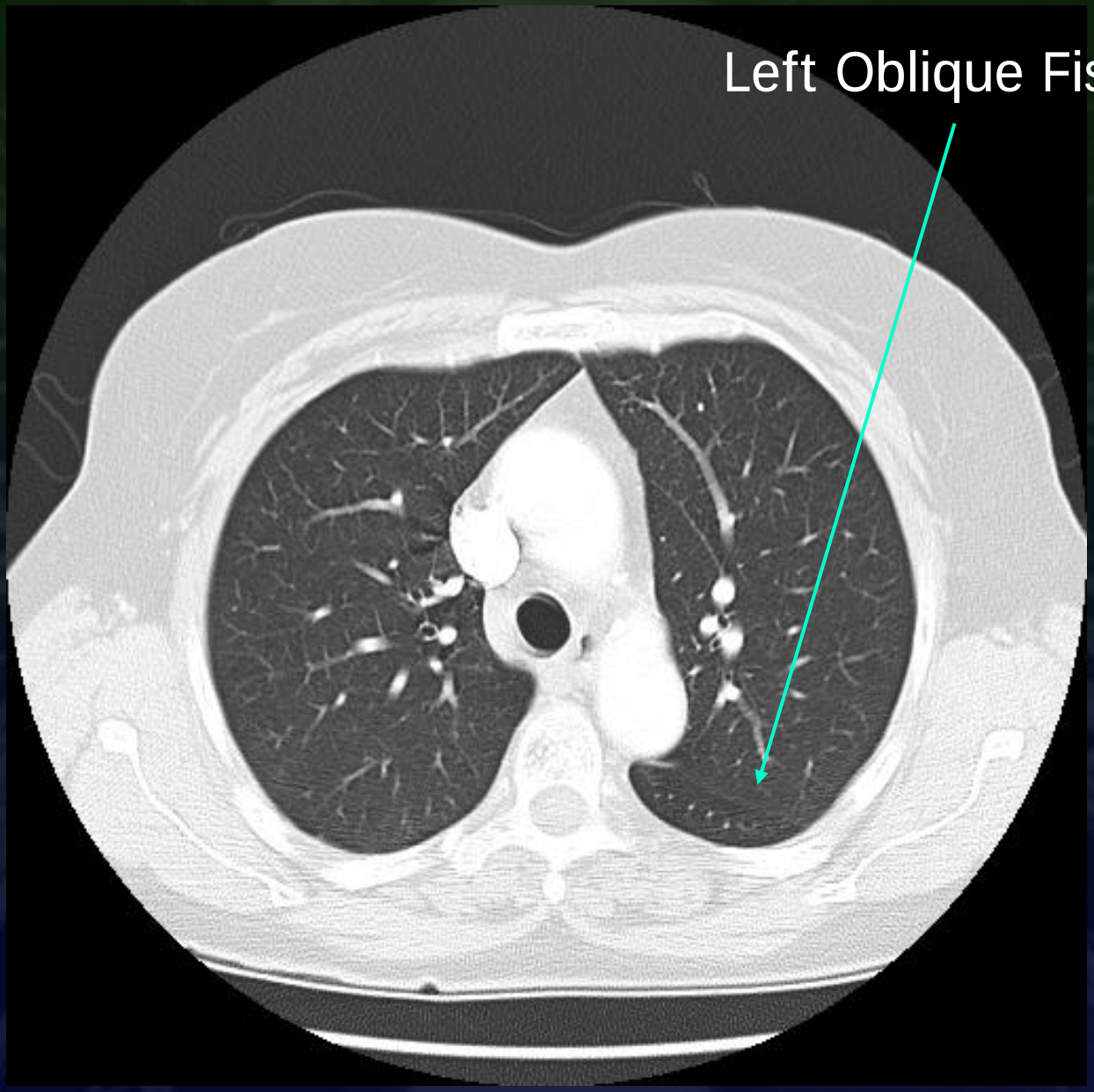
2. At Arch of Aorta

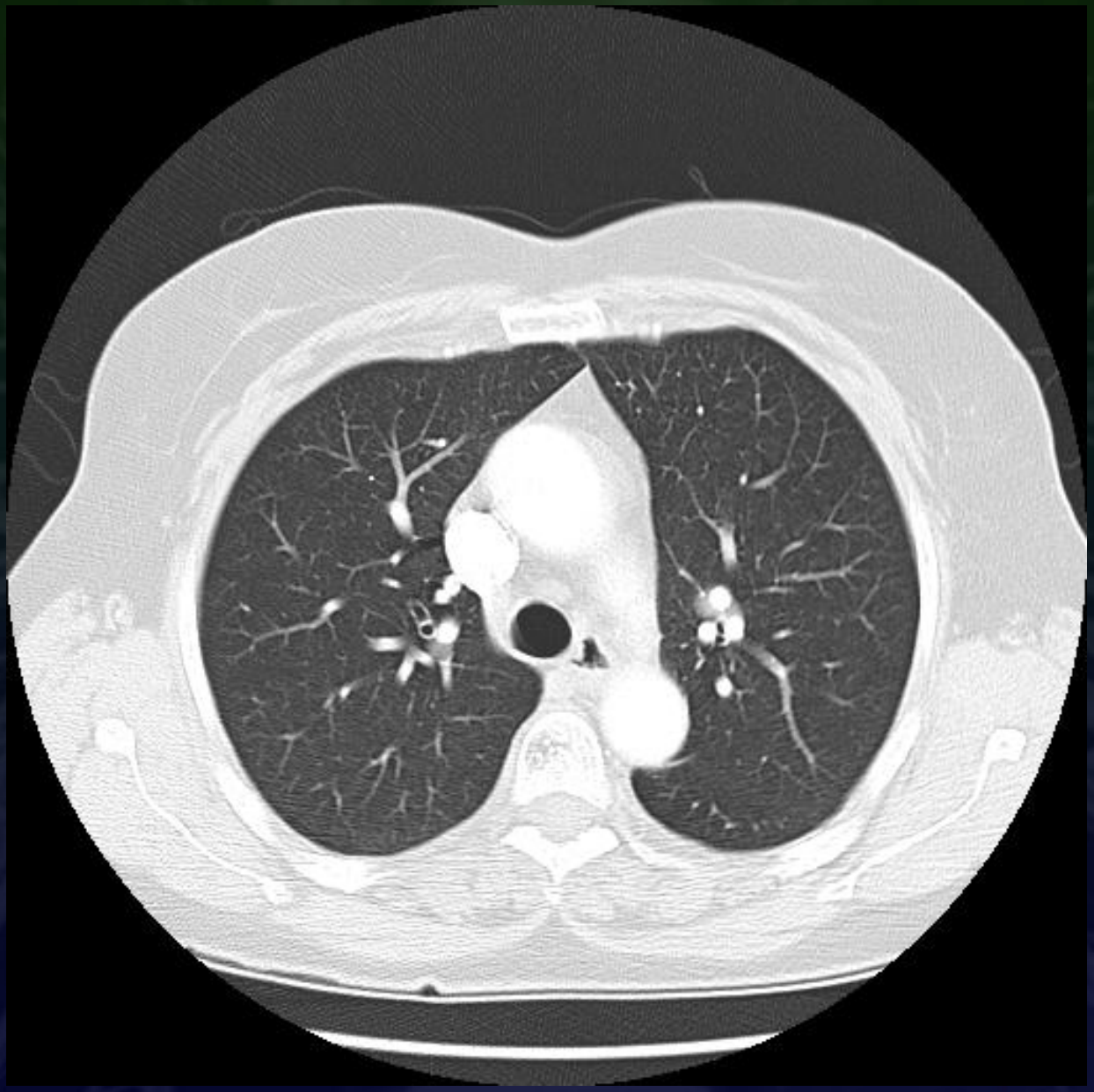


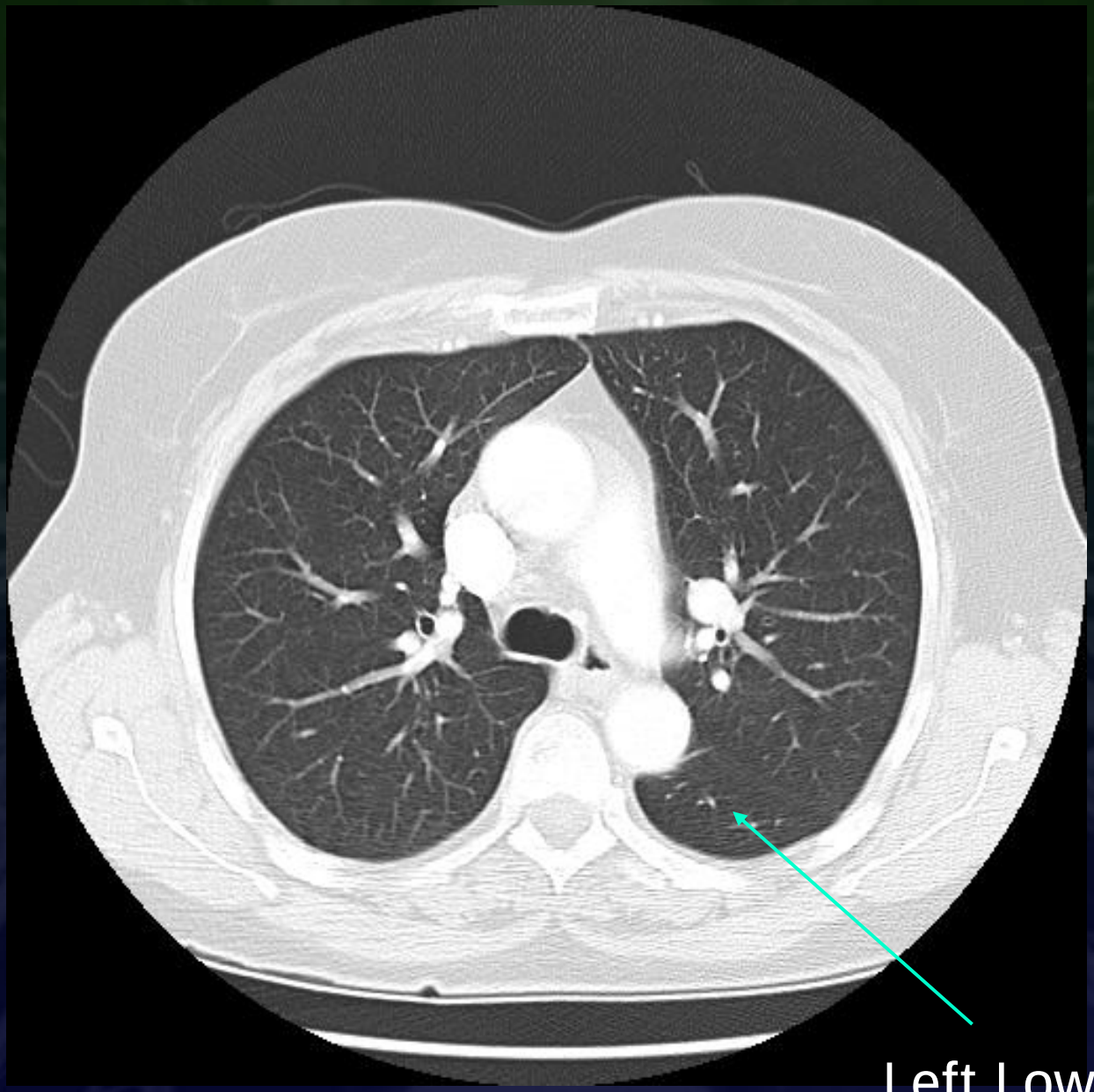
Left
Oblique Fissure

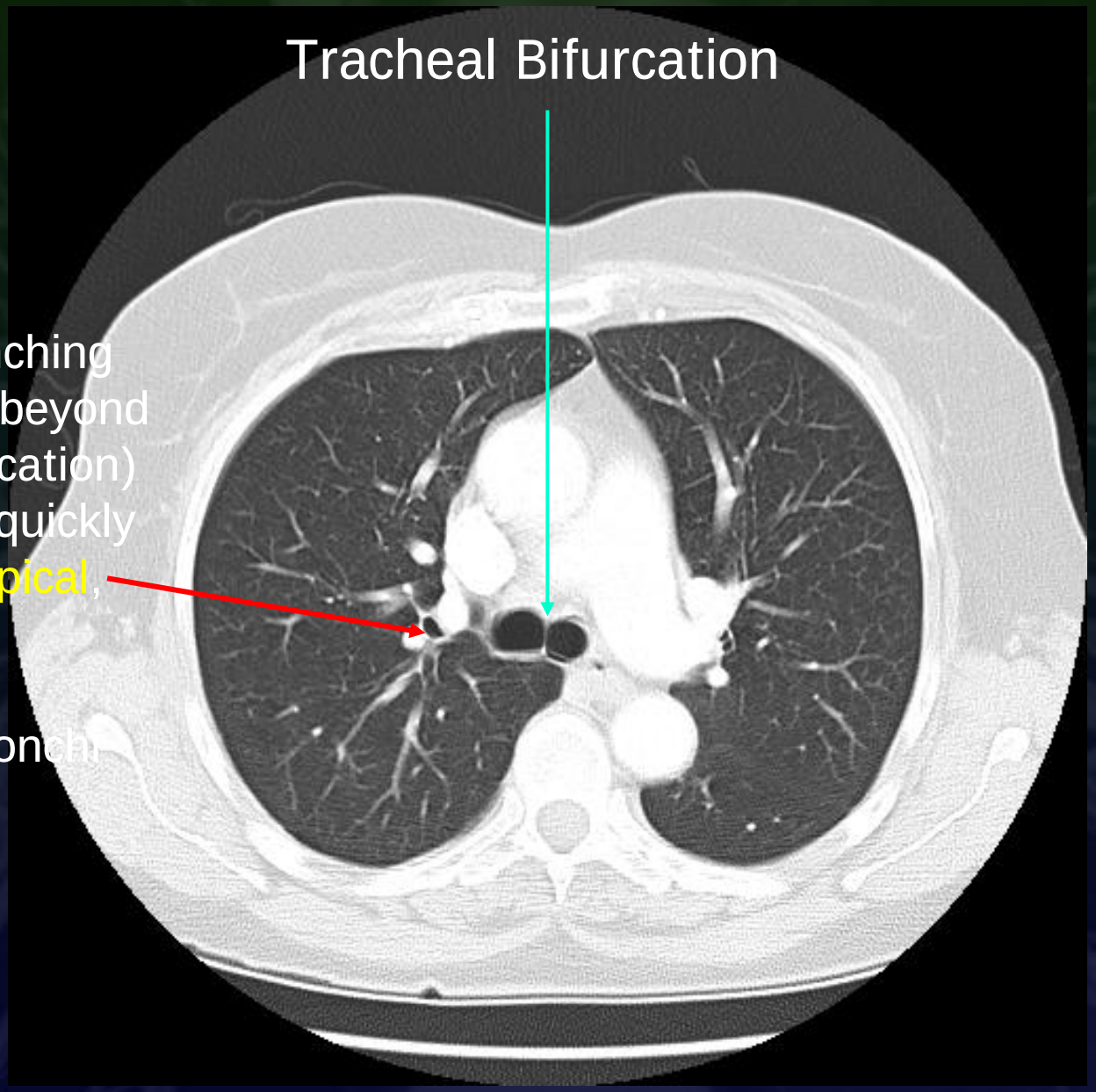




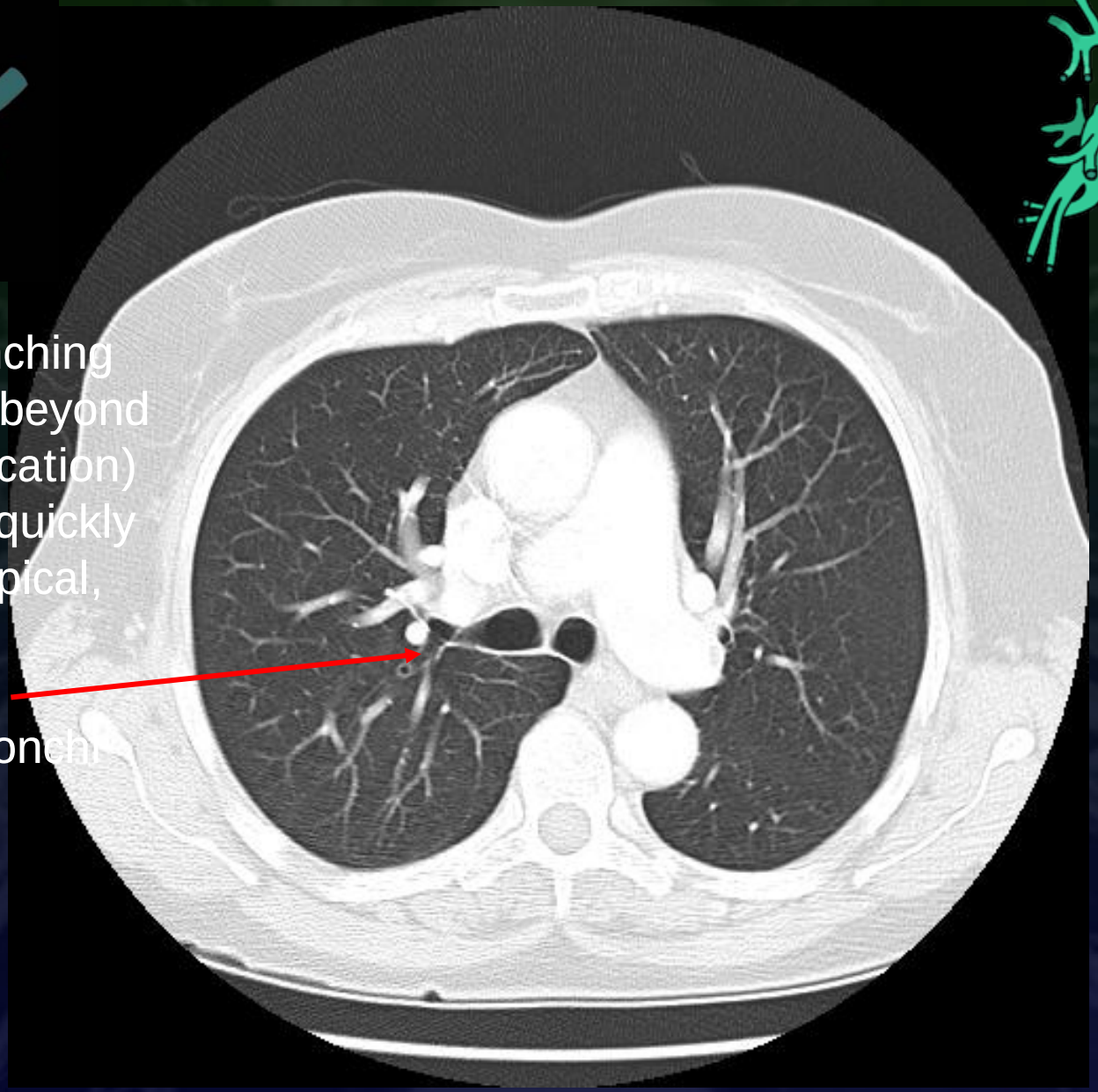

Left Oblique Fissure



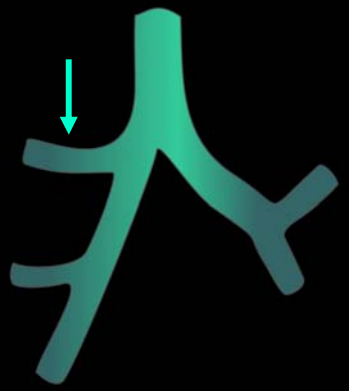

Left Lower Lobe



1st order branching (First branch beyond tracheal bifurcation) – RUL which quickly divides into apical, anterior and posterior segmental bronchi

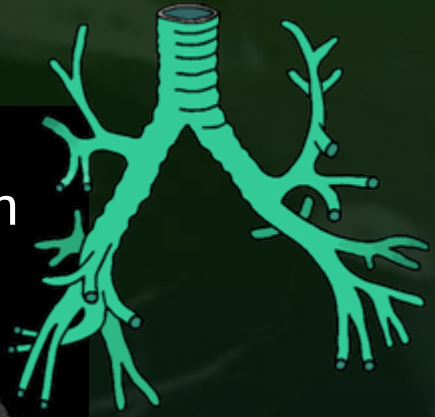


1st order branching (First branch beyond tracheal bifurcation) – RUL which quickly divides into apical, anterior and posterior segmental bronchi

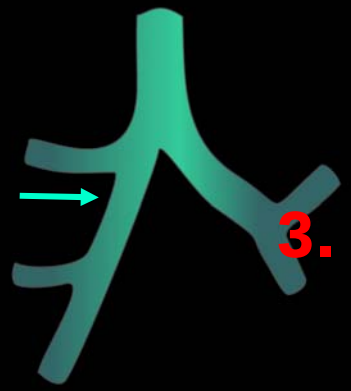


Right Upper Lobe Bronchus

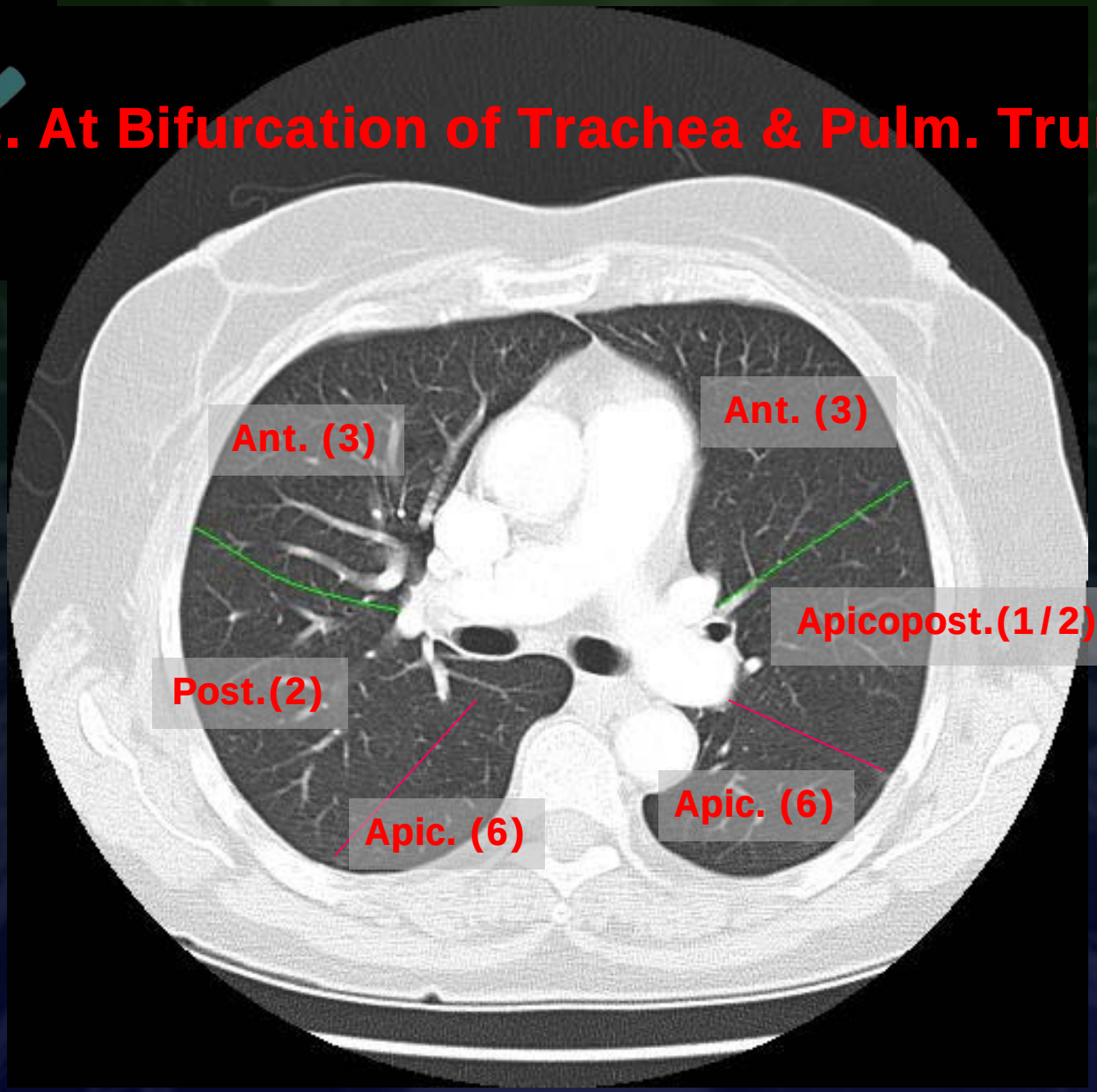
= First branch beyond tracheal bifurcation

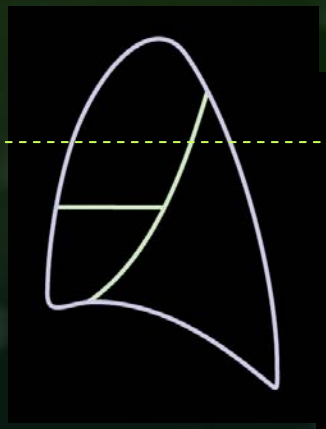


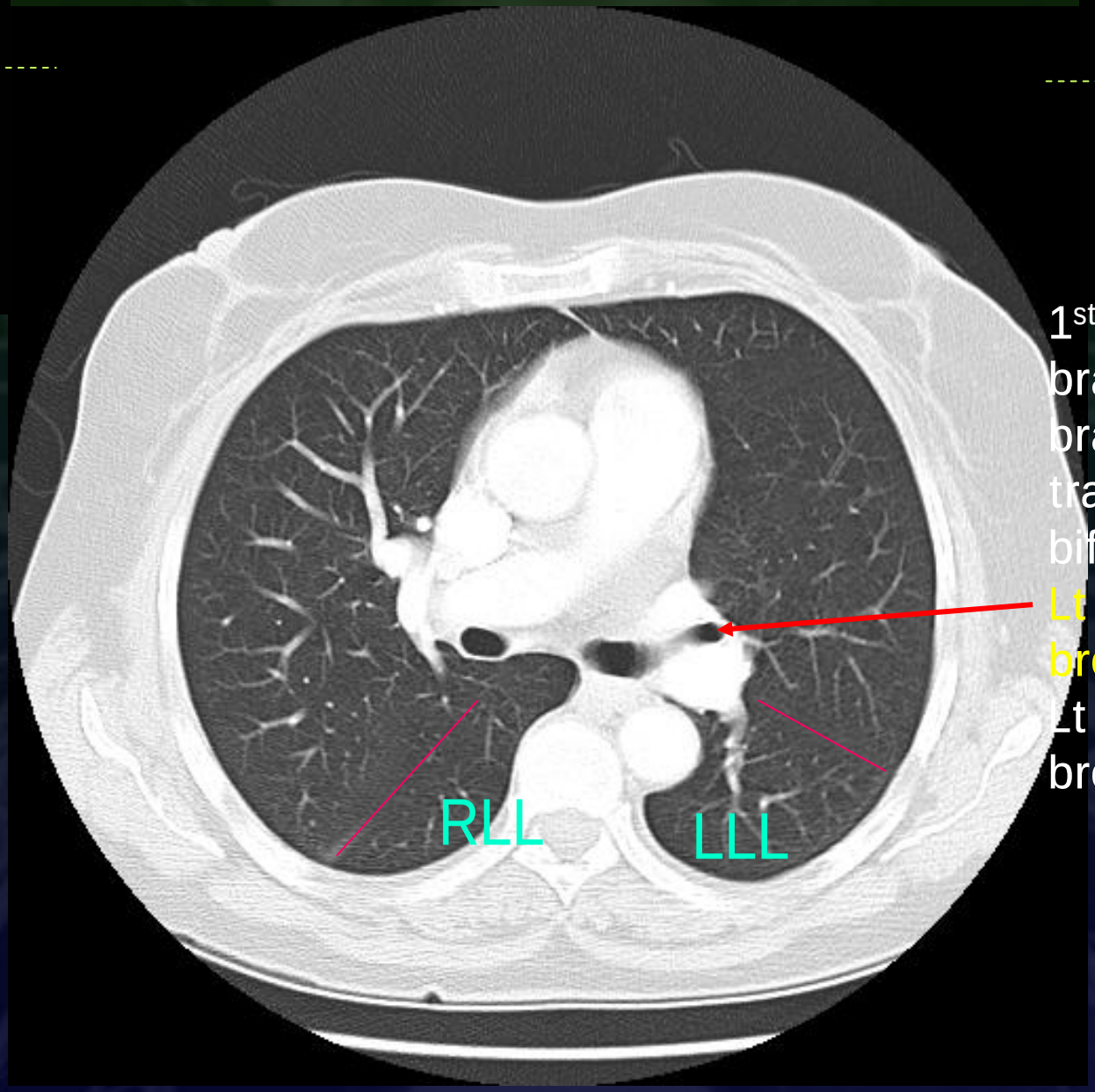
1st order branching (First branch beyond tracheal bifurcation) – RUL which quickly divides into apical, anterior and posterior segmental bronchi

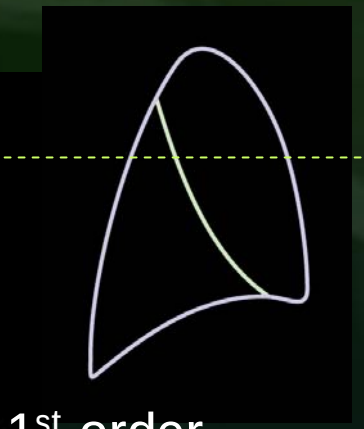


3. At Bifurcation of Trachea & Pulm. Trunk

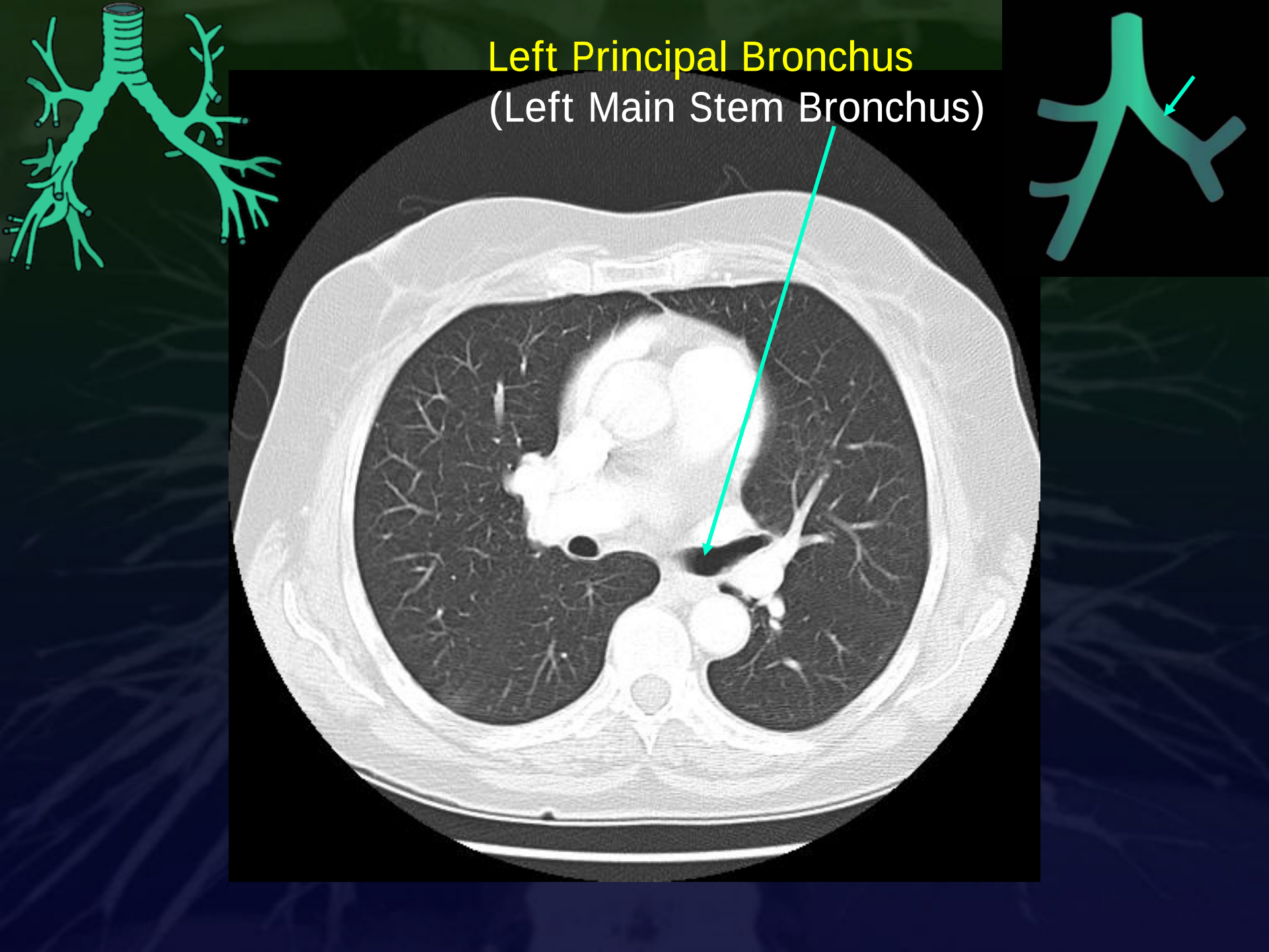


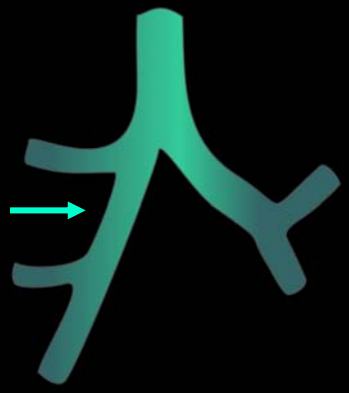




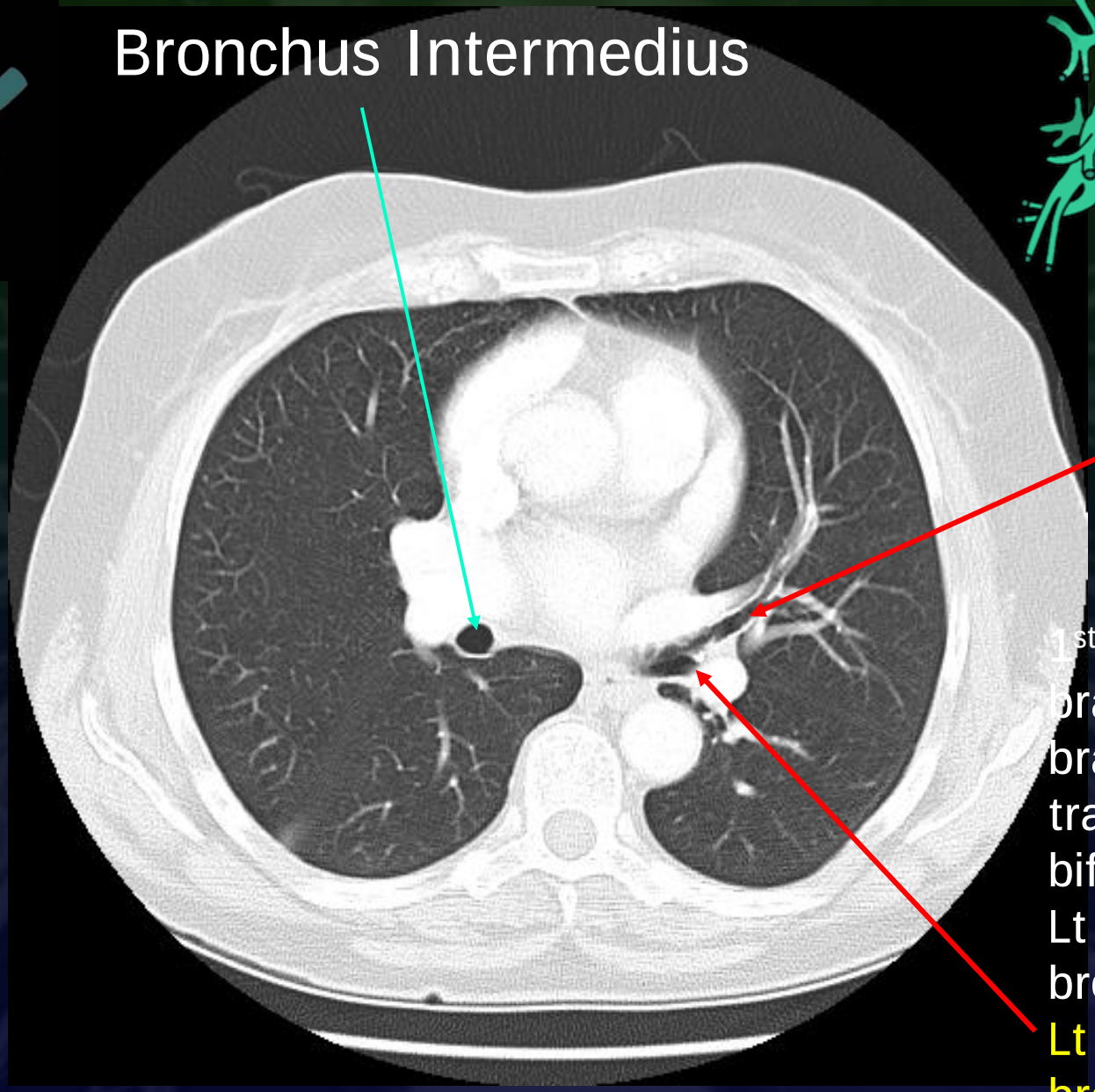


1st order branching (First branch beyond tracheal bifurcation) – Lt Upper Lobar bronchus & Lt Lower Lobar bronchus


Left Principal Bronchus
(Left Main Stem Bronchus)



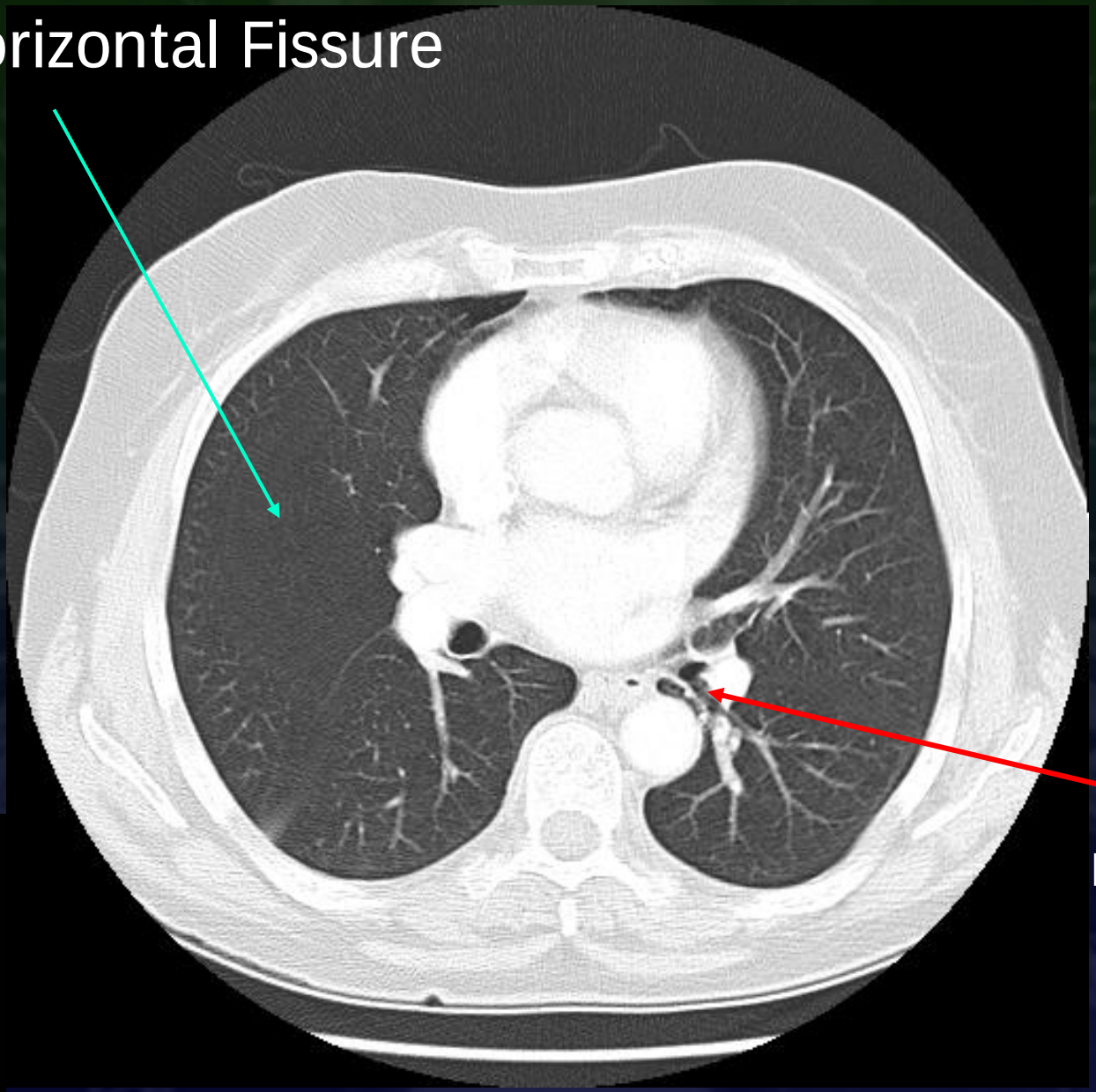
Bronchus Intermedius



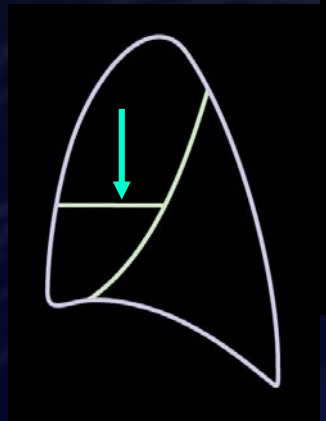
lingular segment LUL

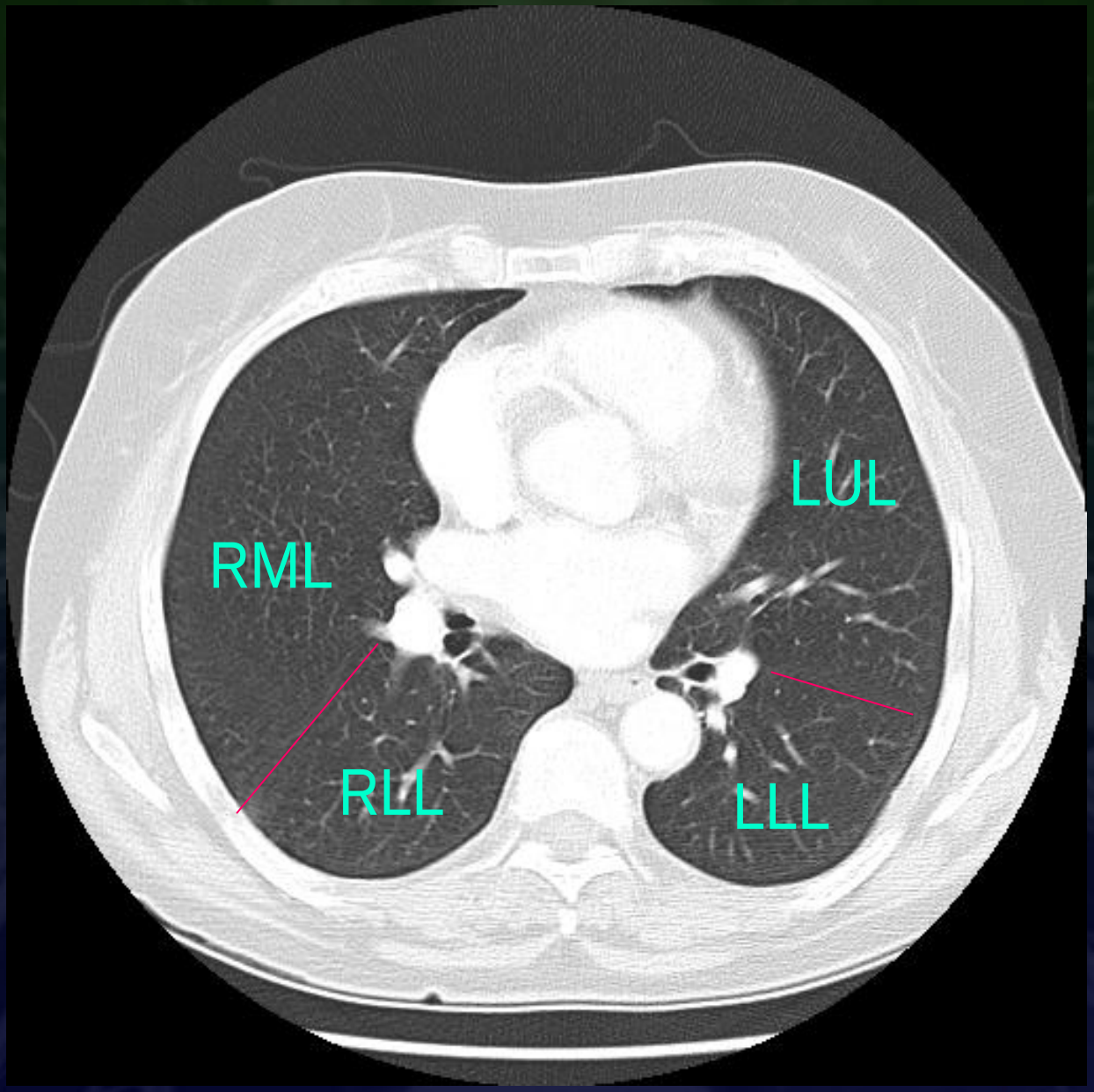
1st order branching (First branch beyond tracheal bifurcation) – Lt Upper Lobar bronchus & Lt Lower Lobar bronchus

Horizontal Fissure

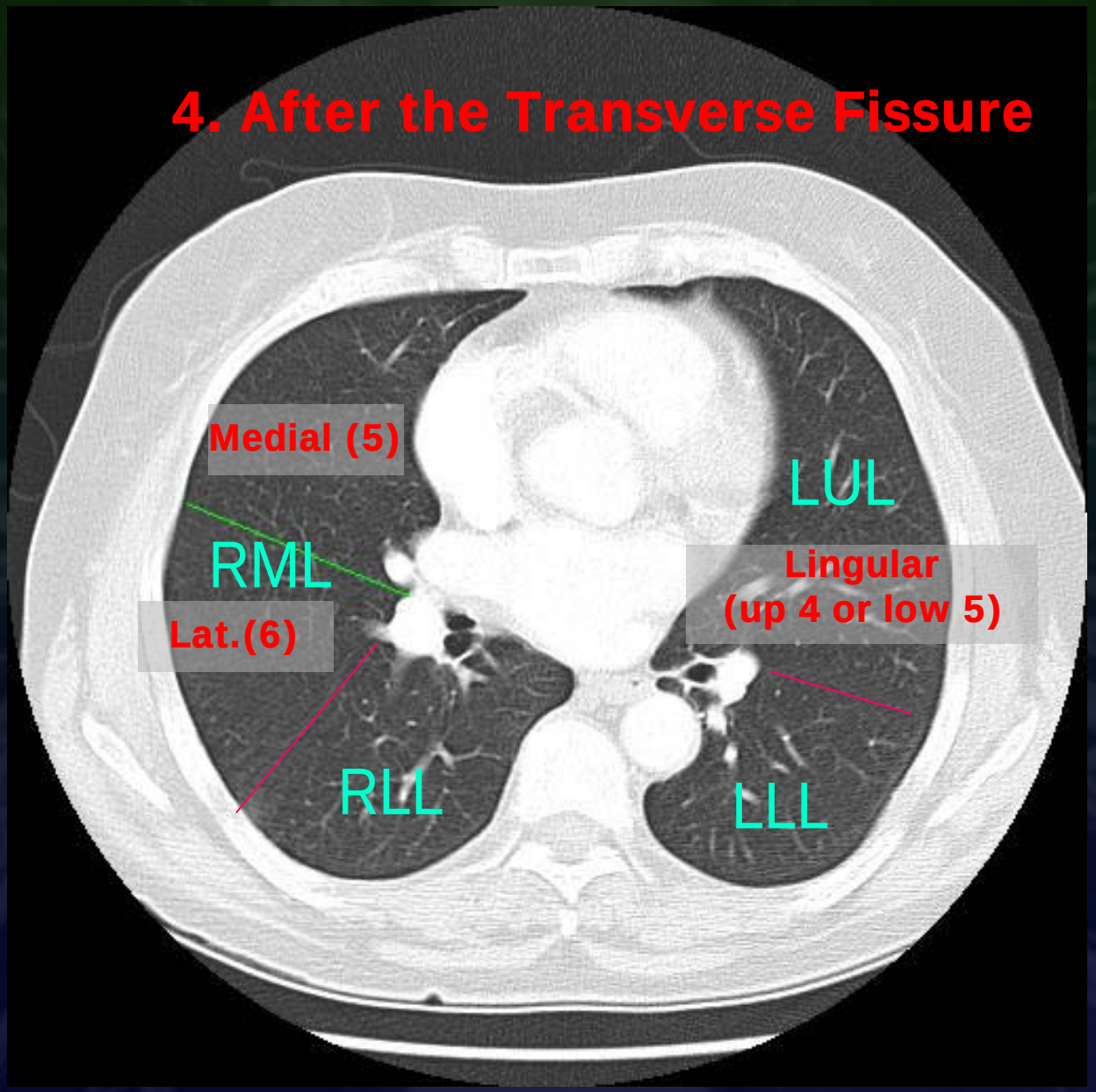


superior segment LLL bronchus




RML
RLL
LUL
LLL

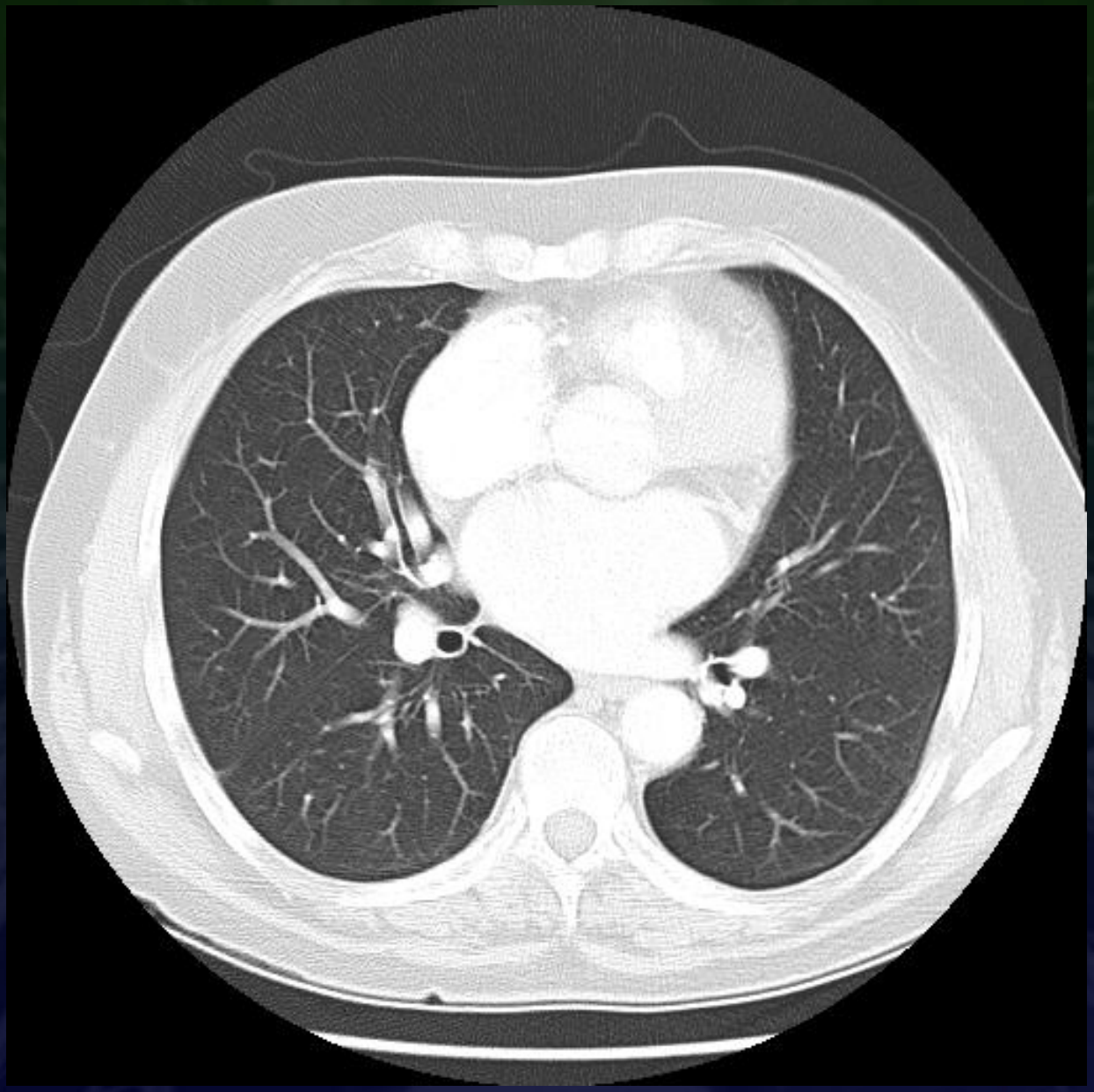
4. After the Transverse Fissure

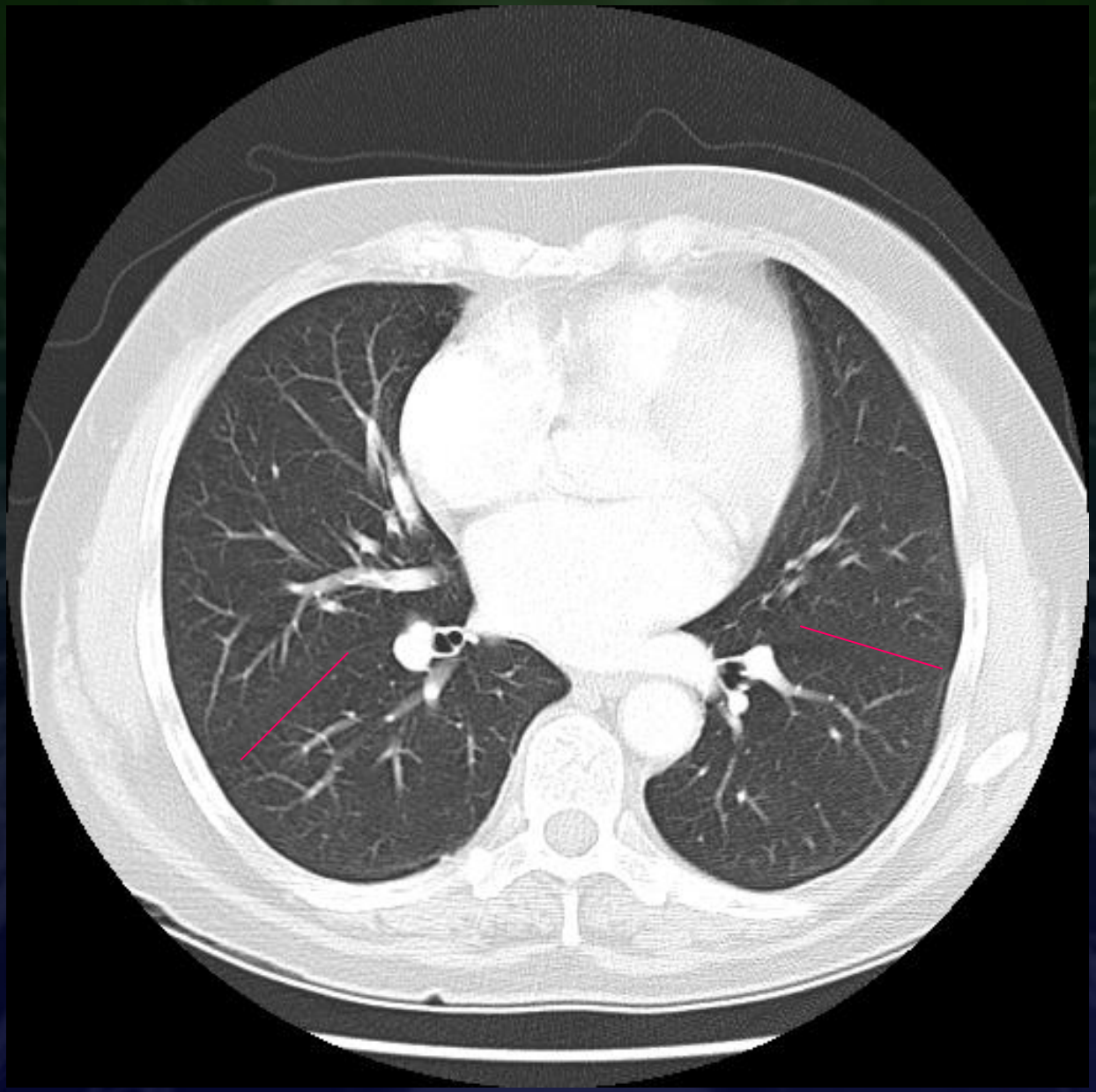


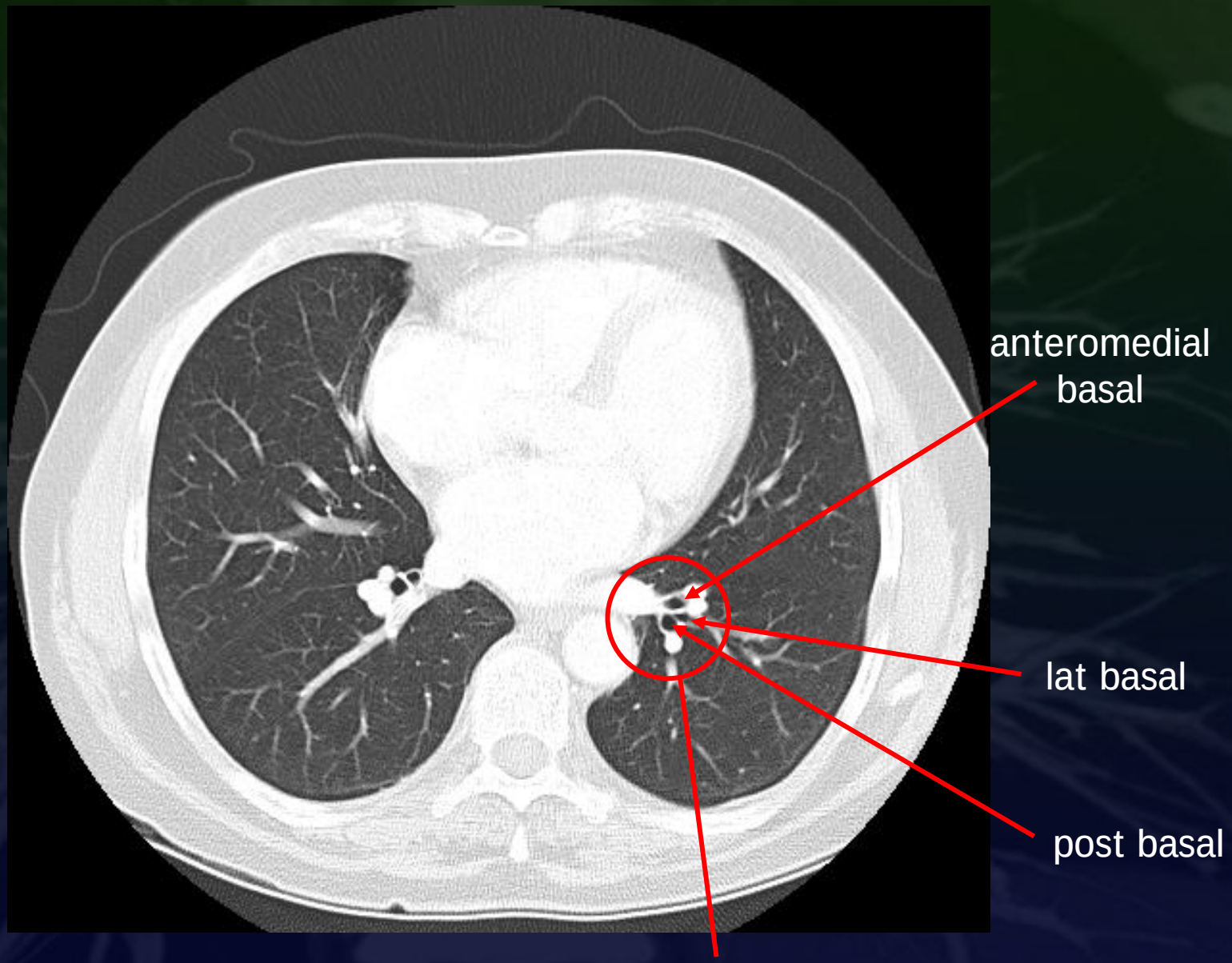
RML branch

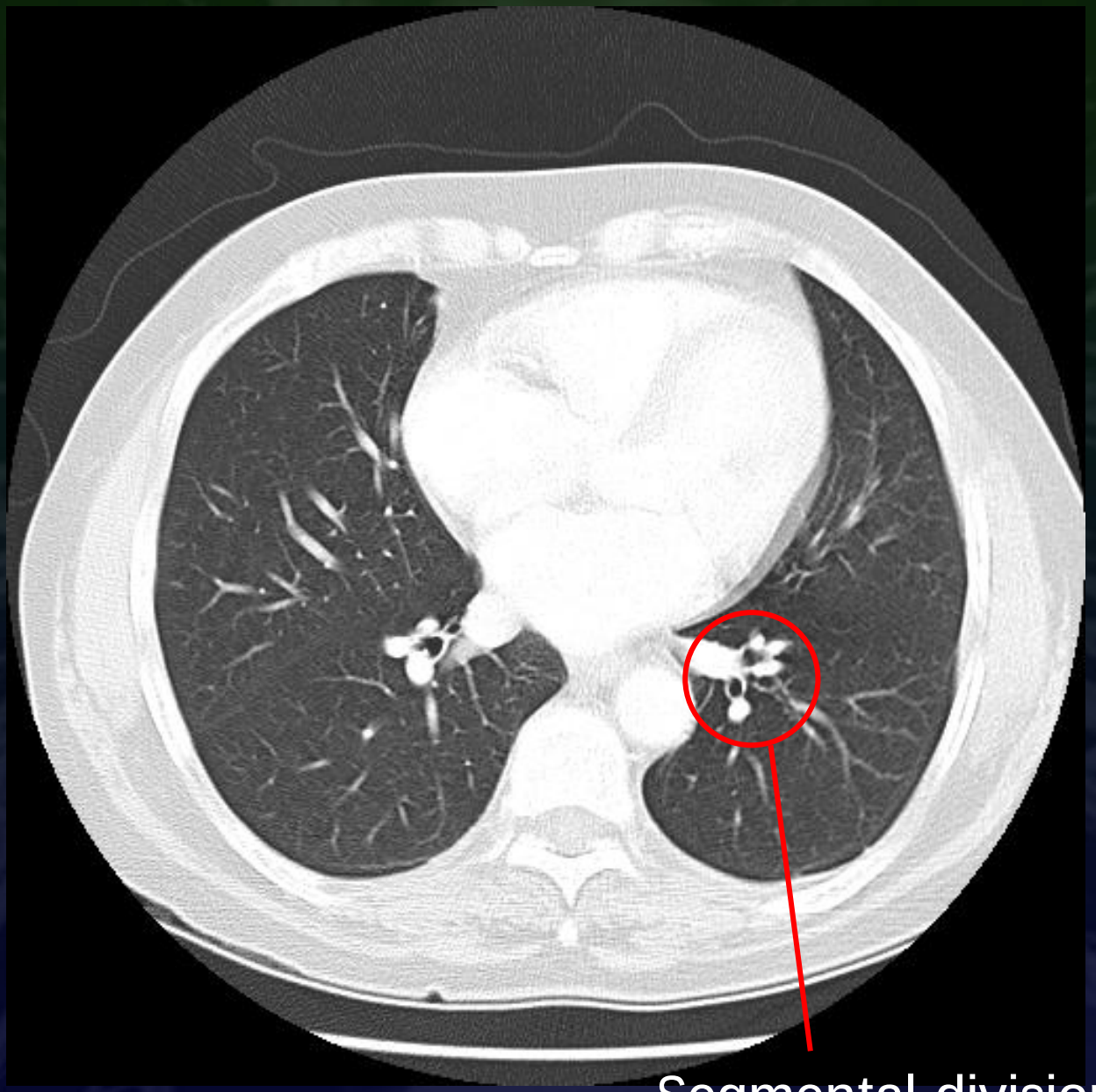
2nd order branching – RML & RLL

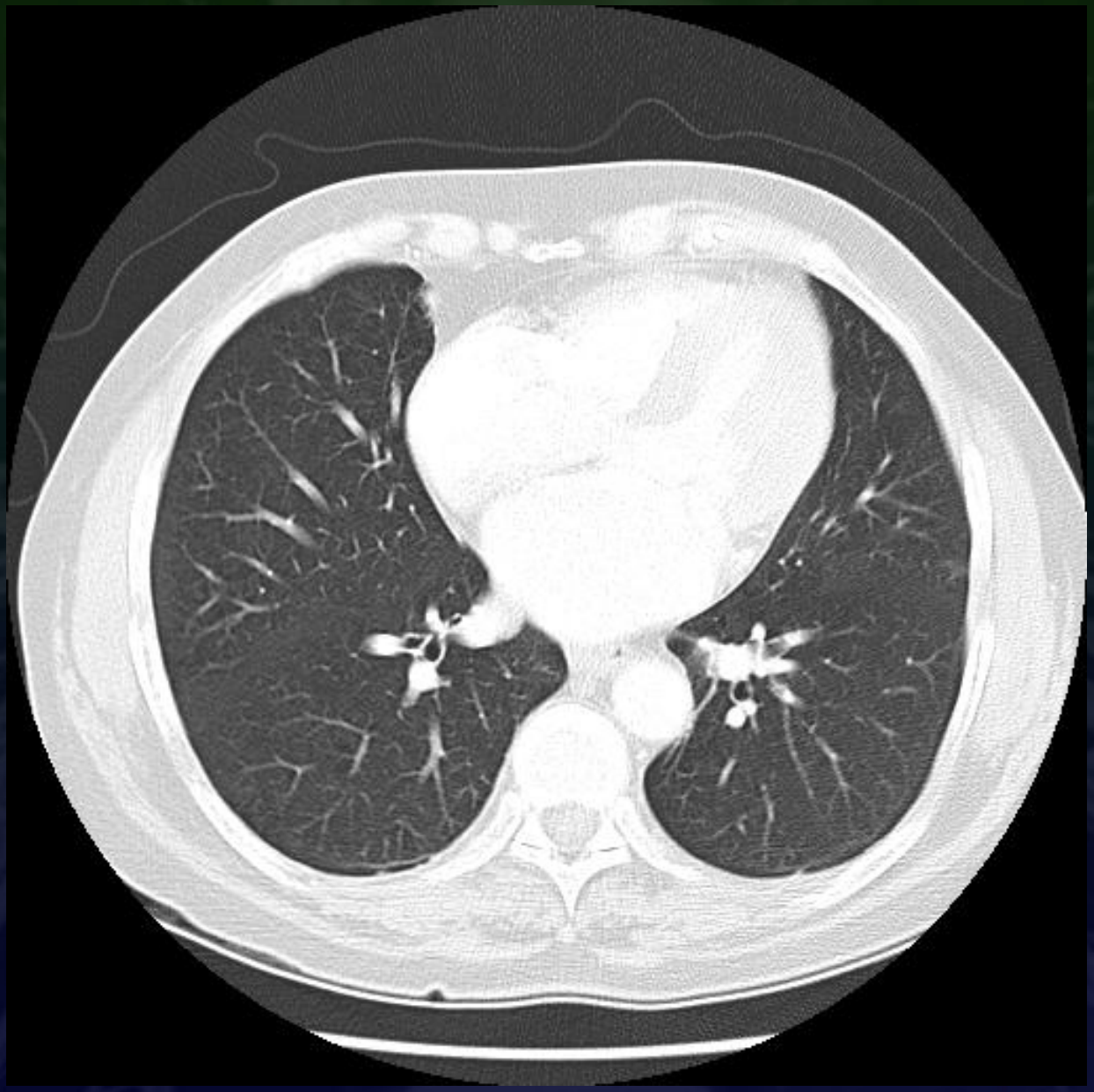
RLL branch

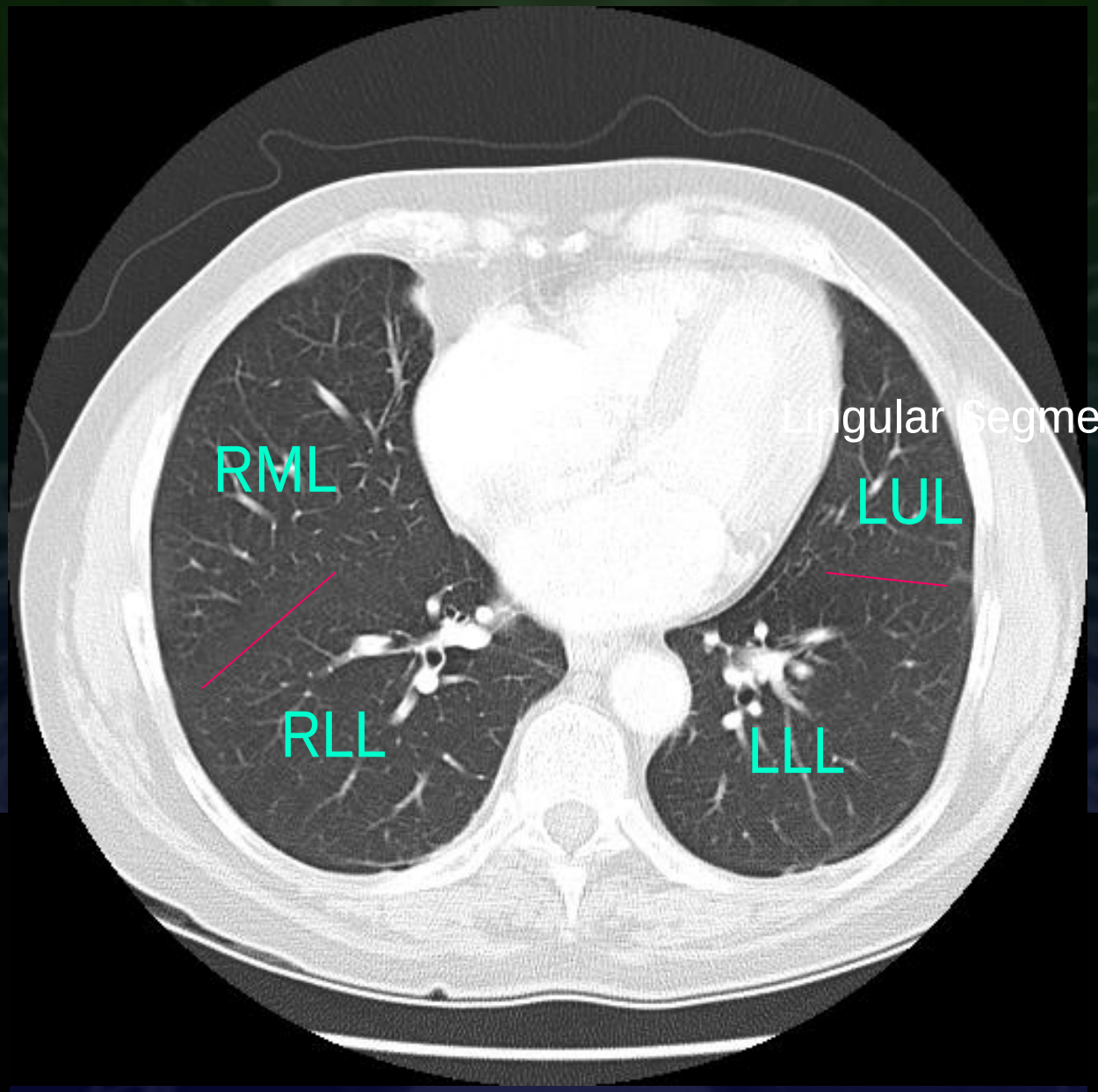


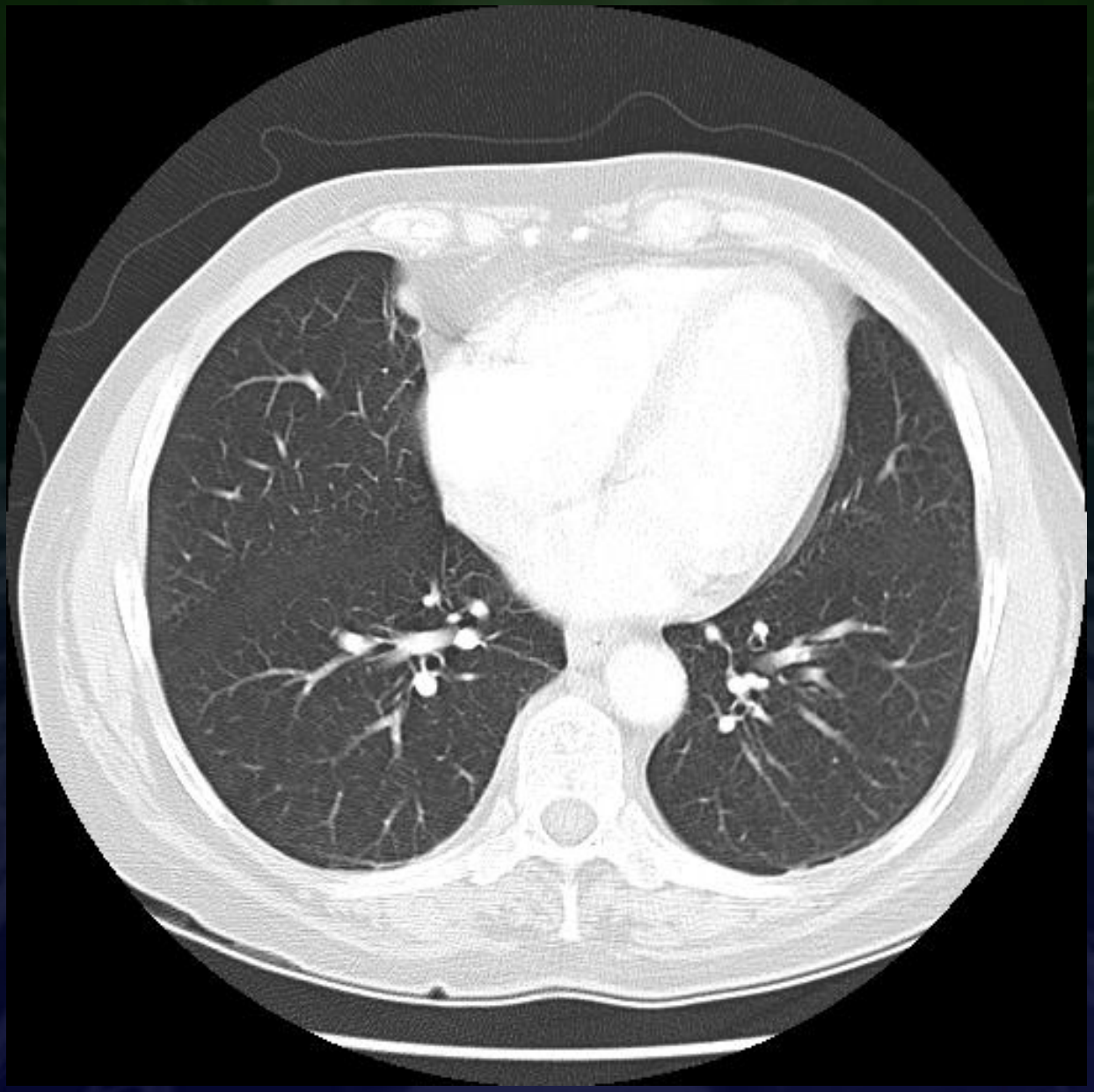


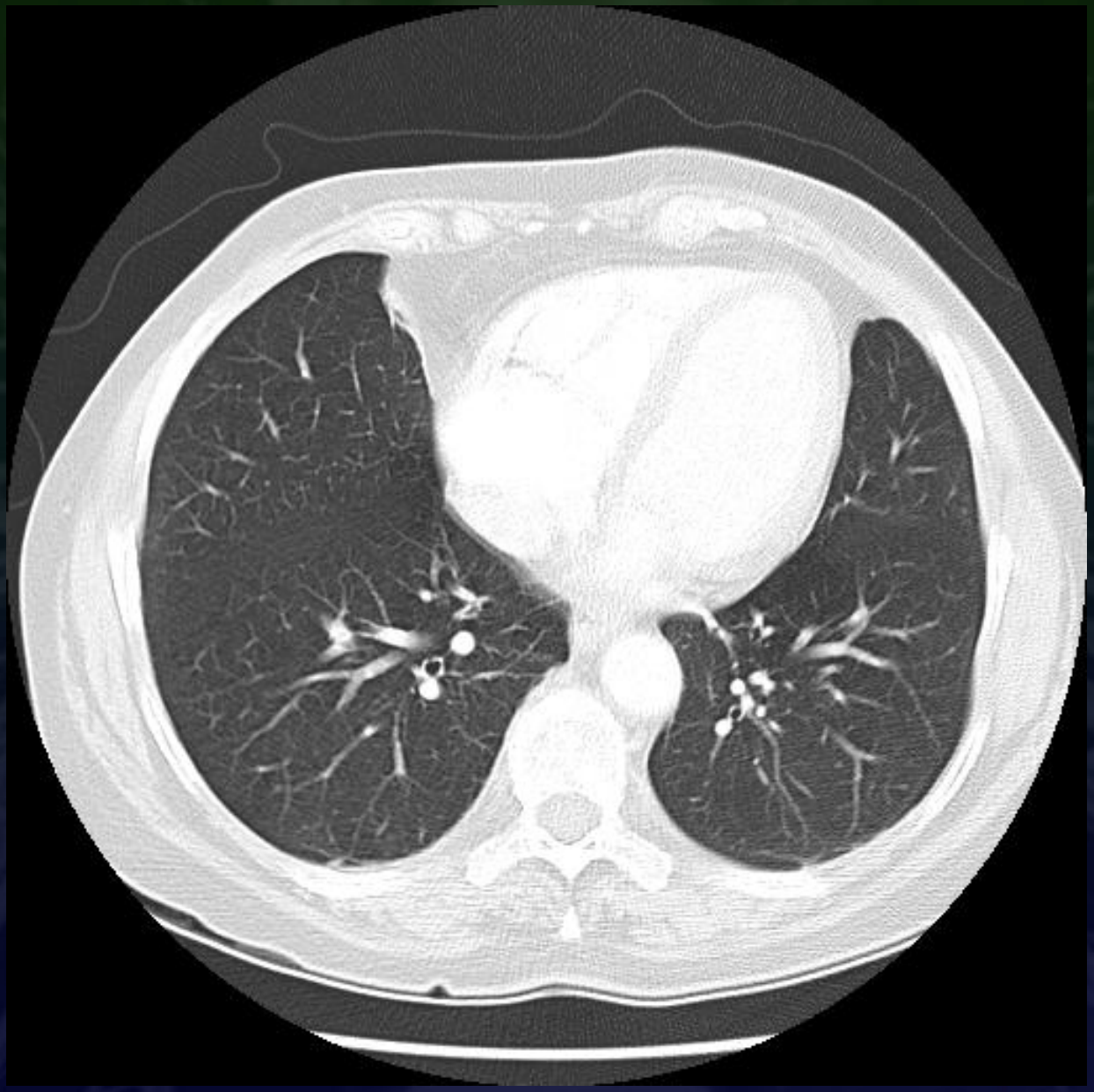

anteromedial basal
lat basal
post basal
Segmental divisions

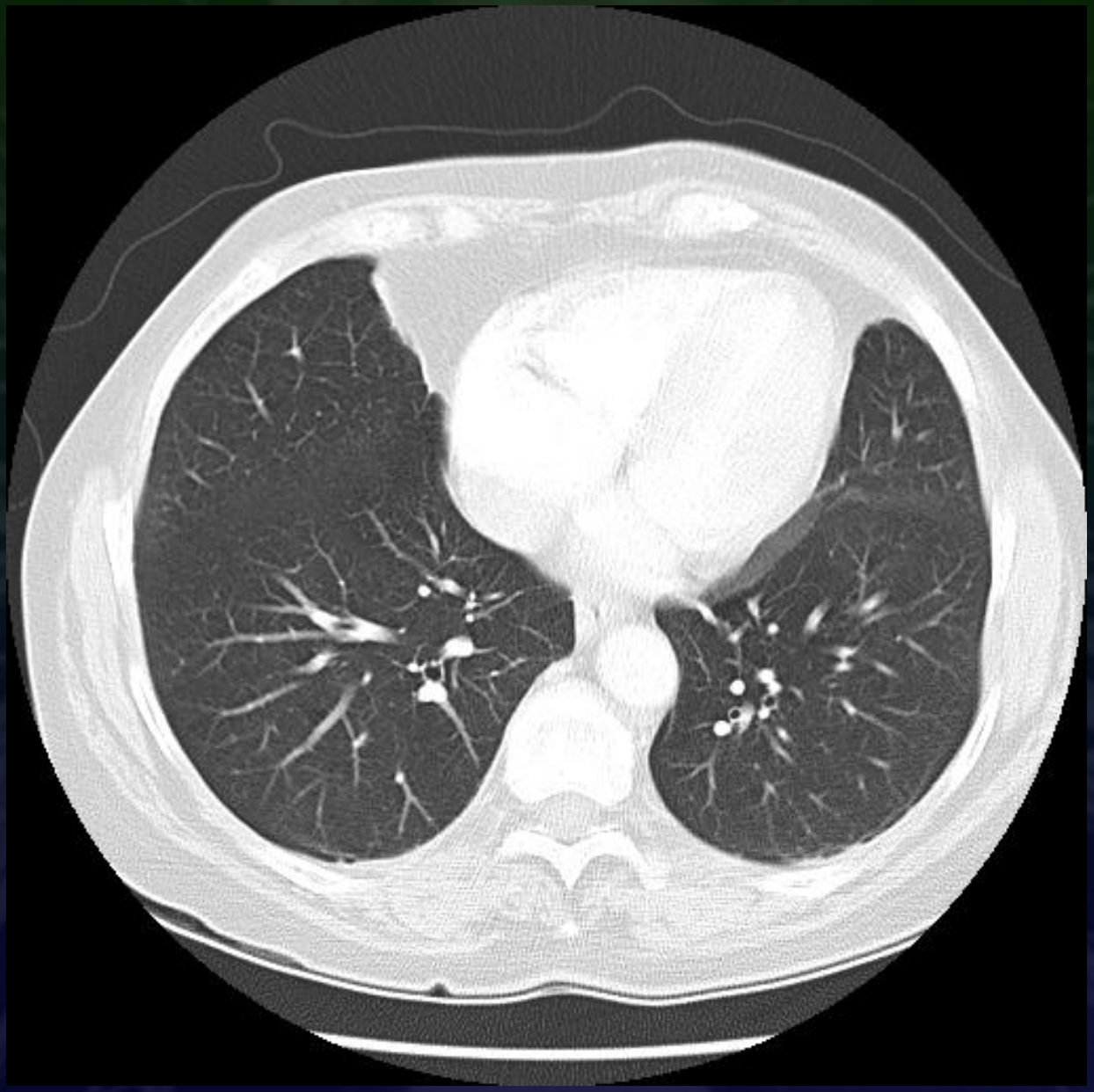

Segmental divisions

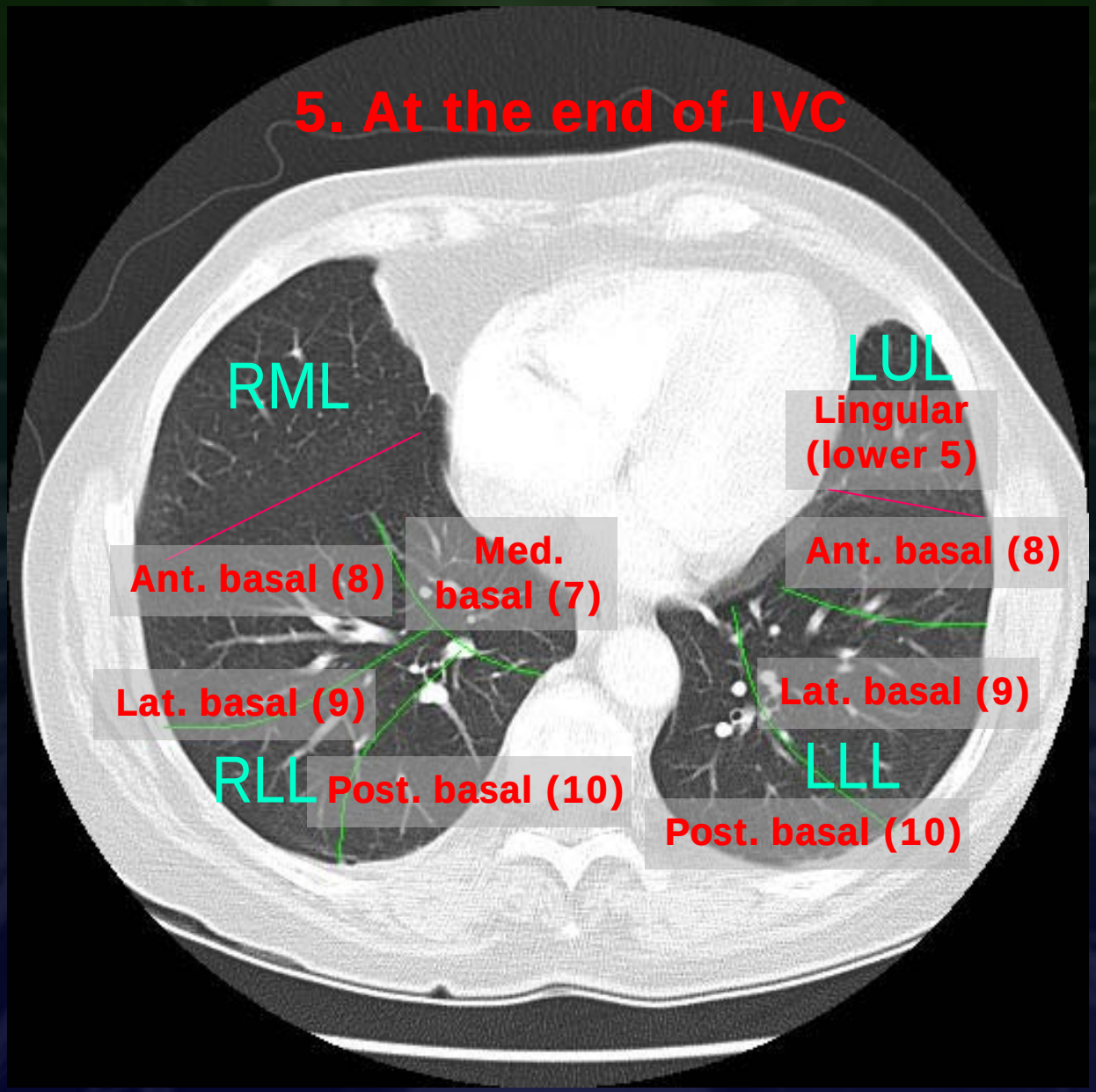


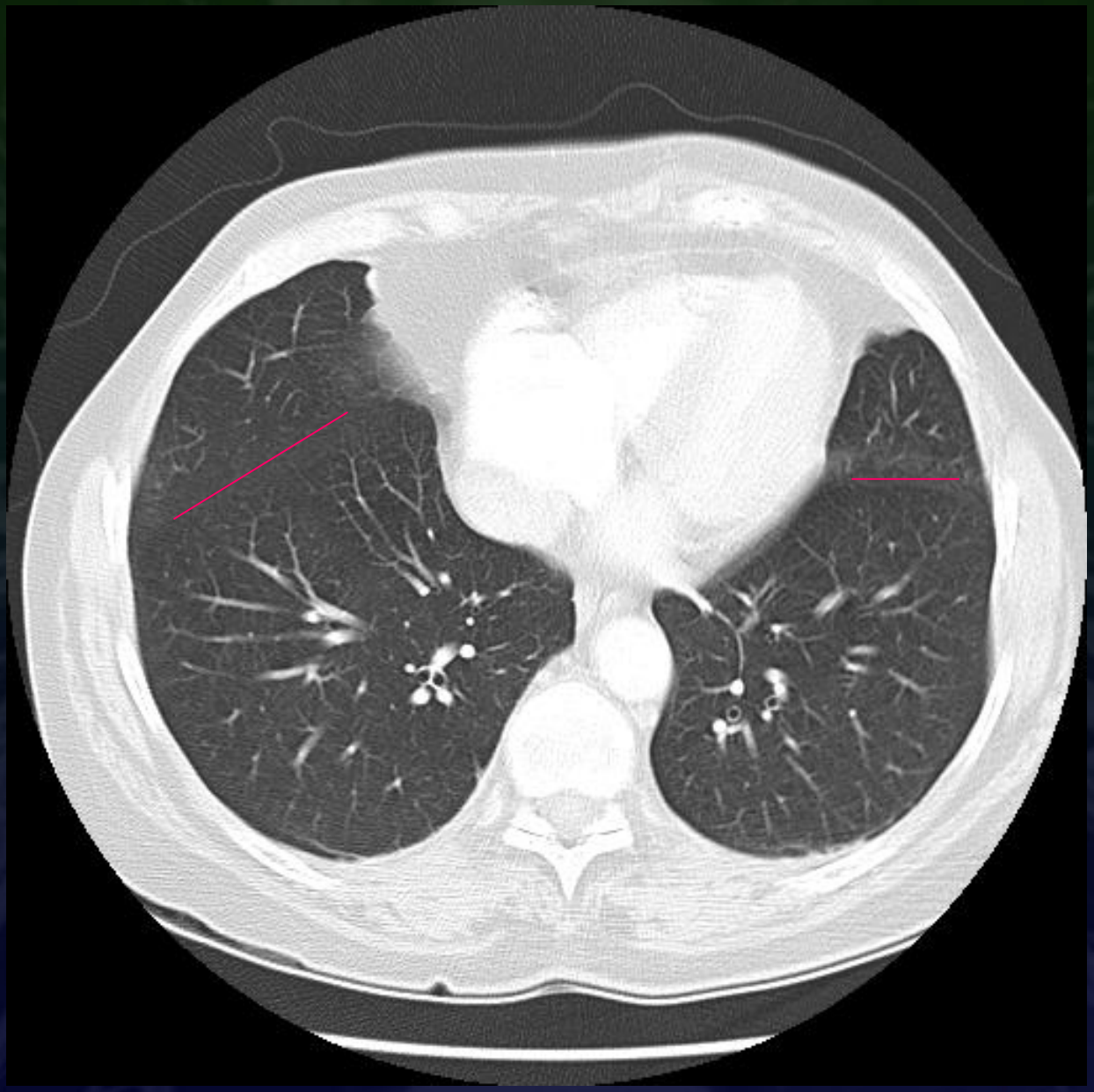

Lingular Segment
RML
LUL
RLL
LLL

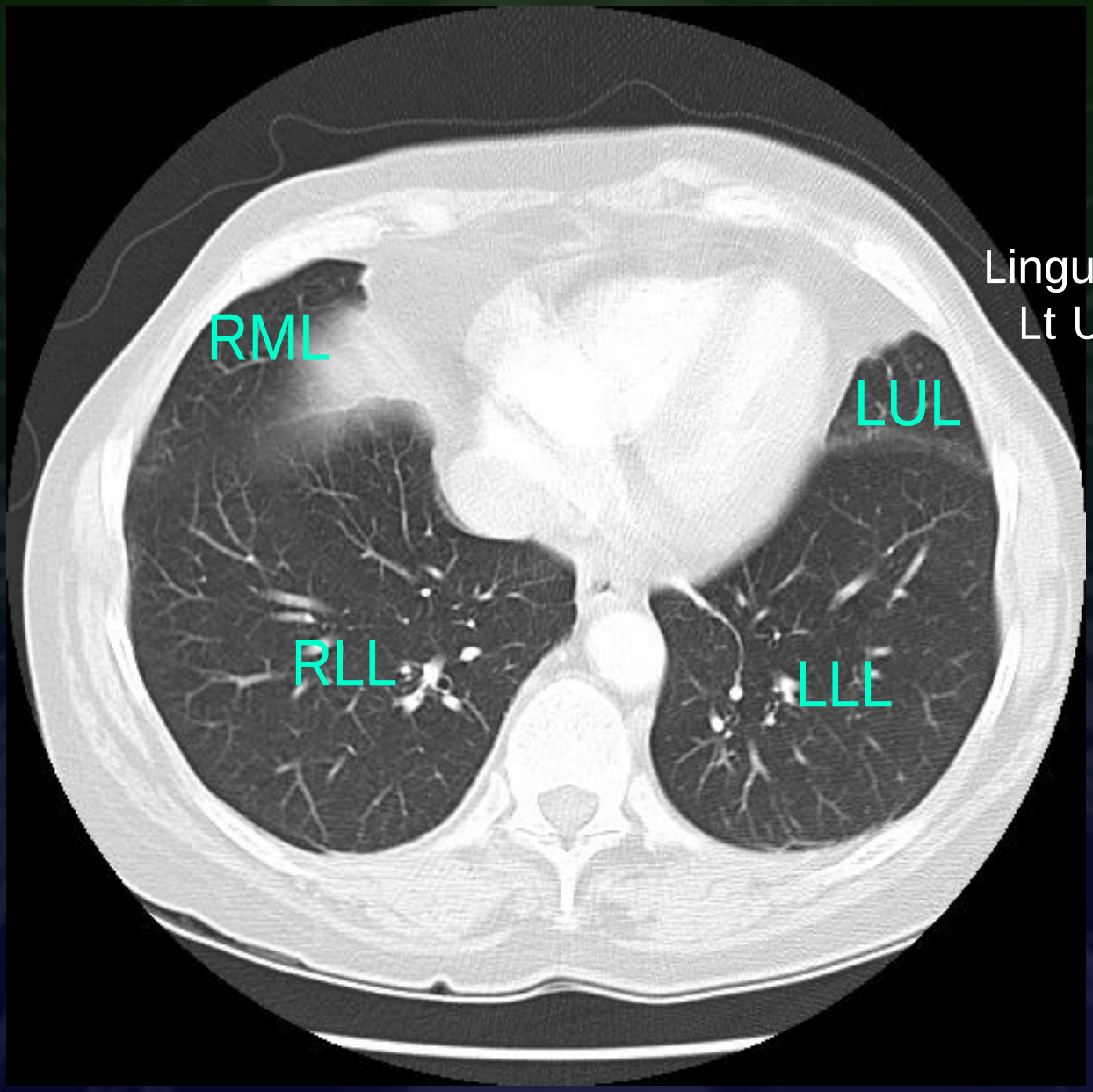




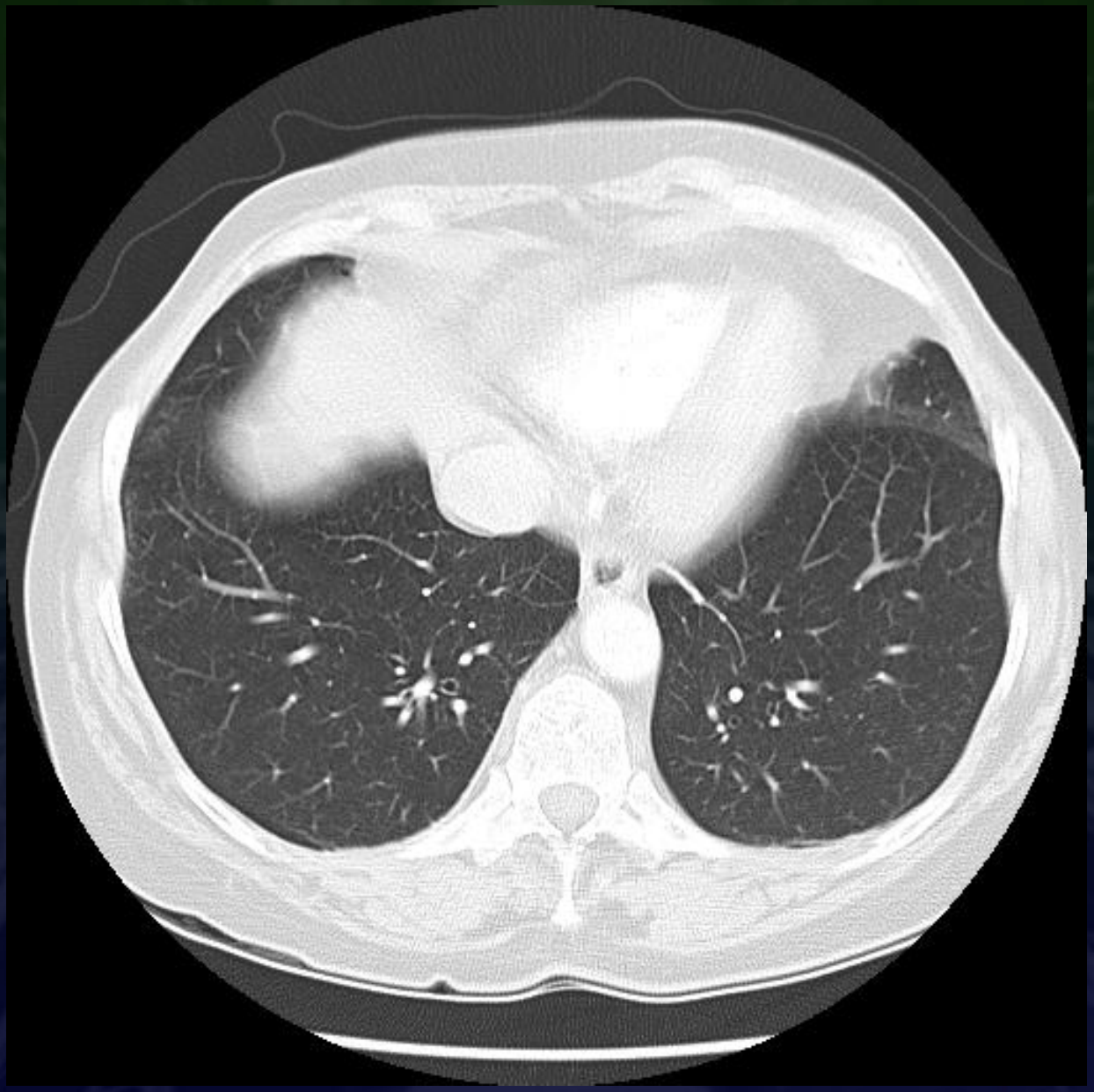


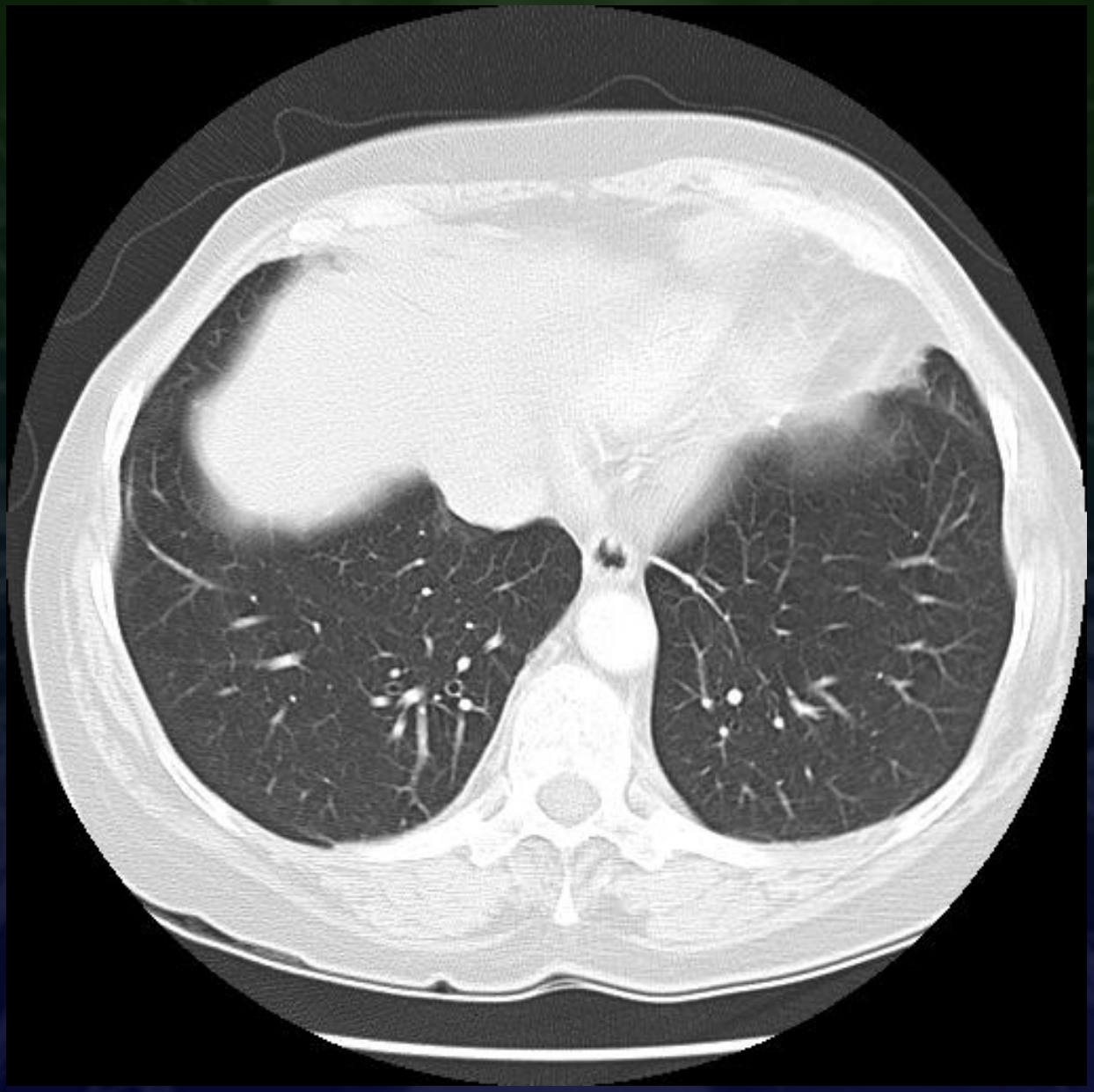

5. At the end of IVC
RML
Ant. basal (8)
Med. basal (7)
Lat. basal (9)
RLL
Post. basal (10)
LUL
Lingular (lower 5)
Ant. basal (8)
Lat. basal (9)
LLL
Post. basal (10)

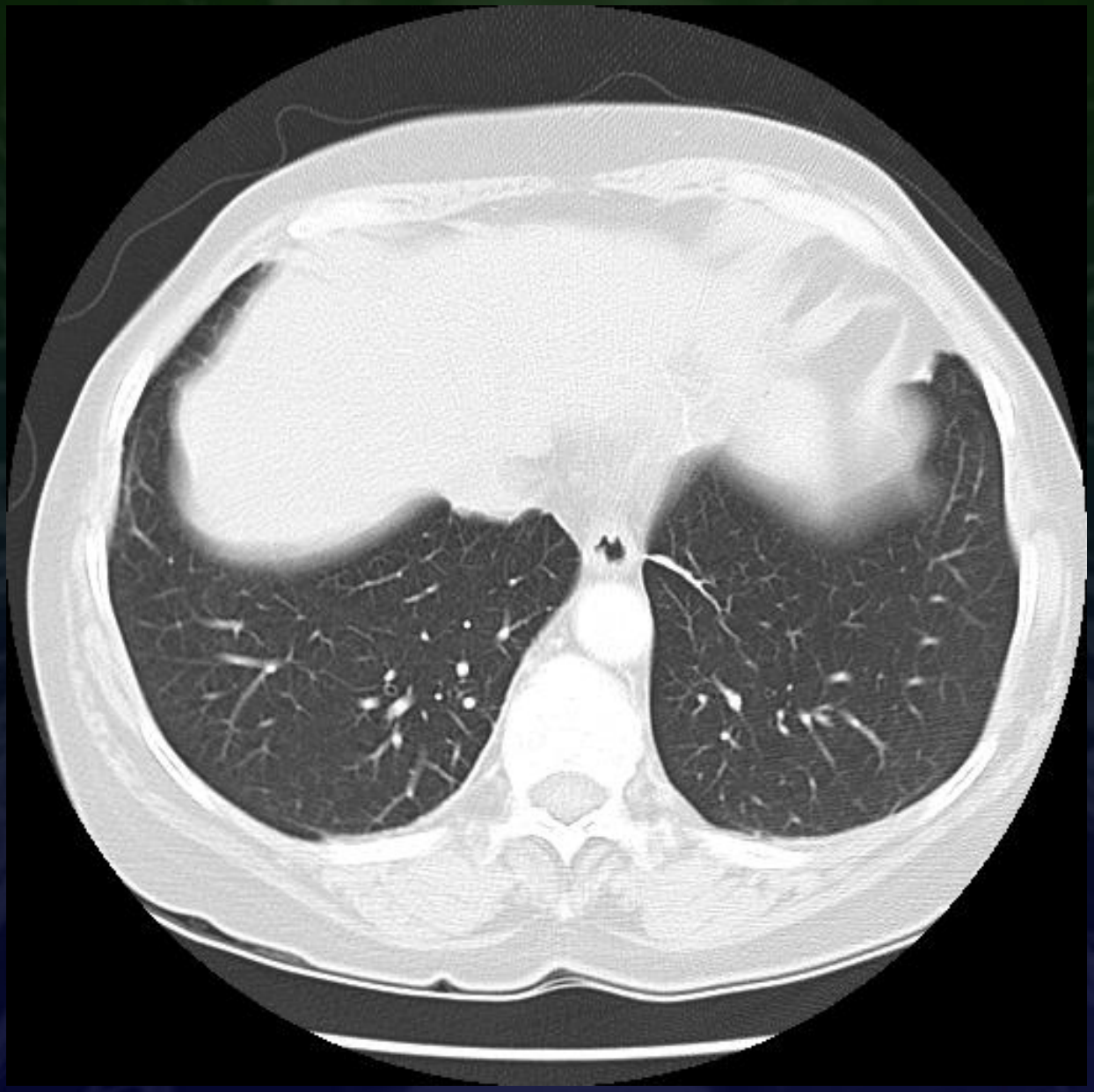


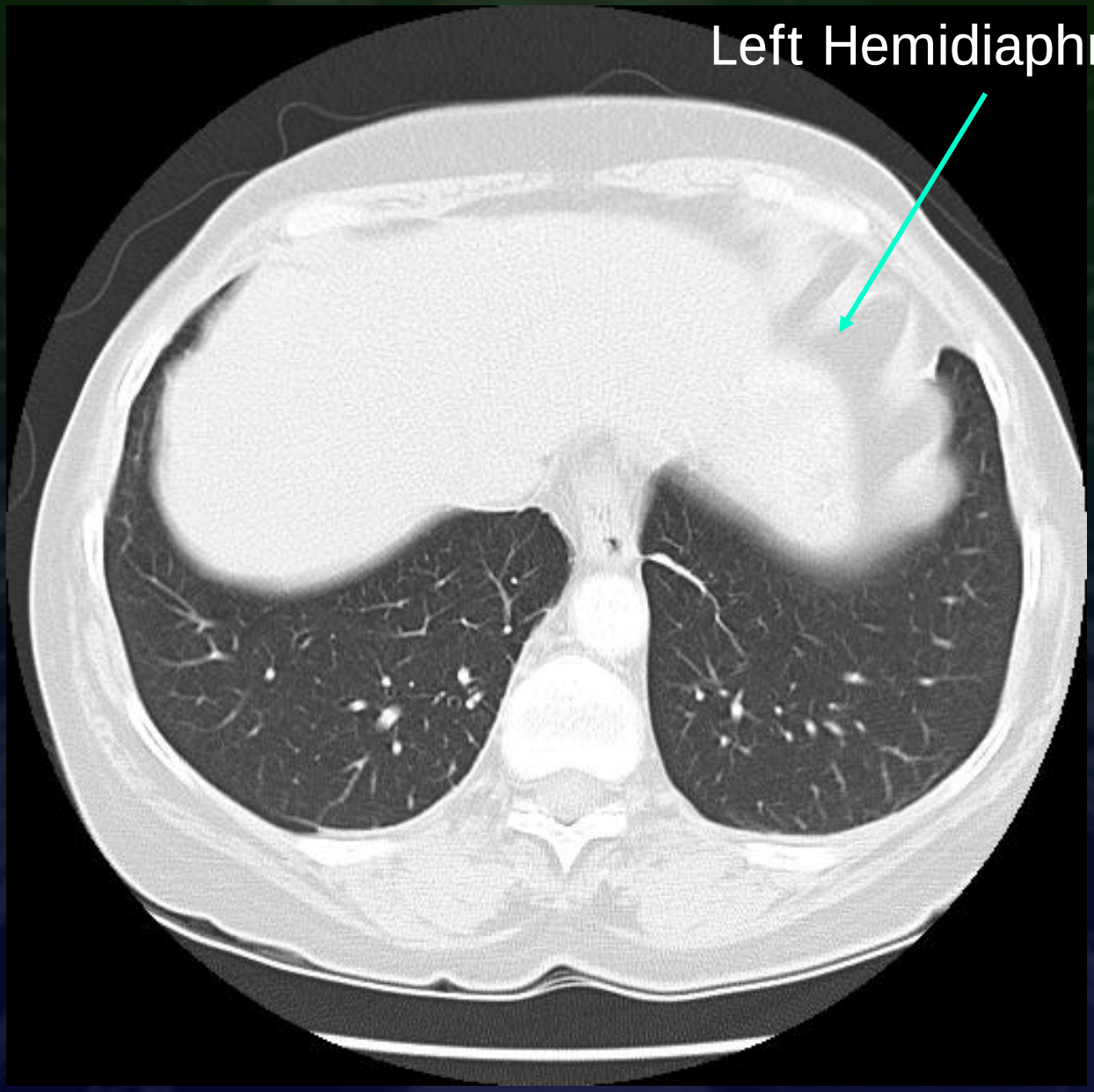


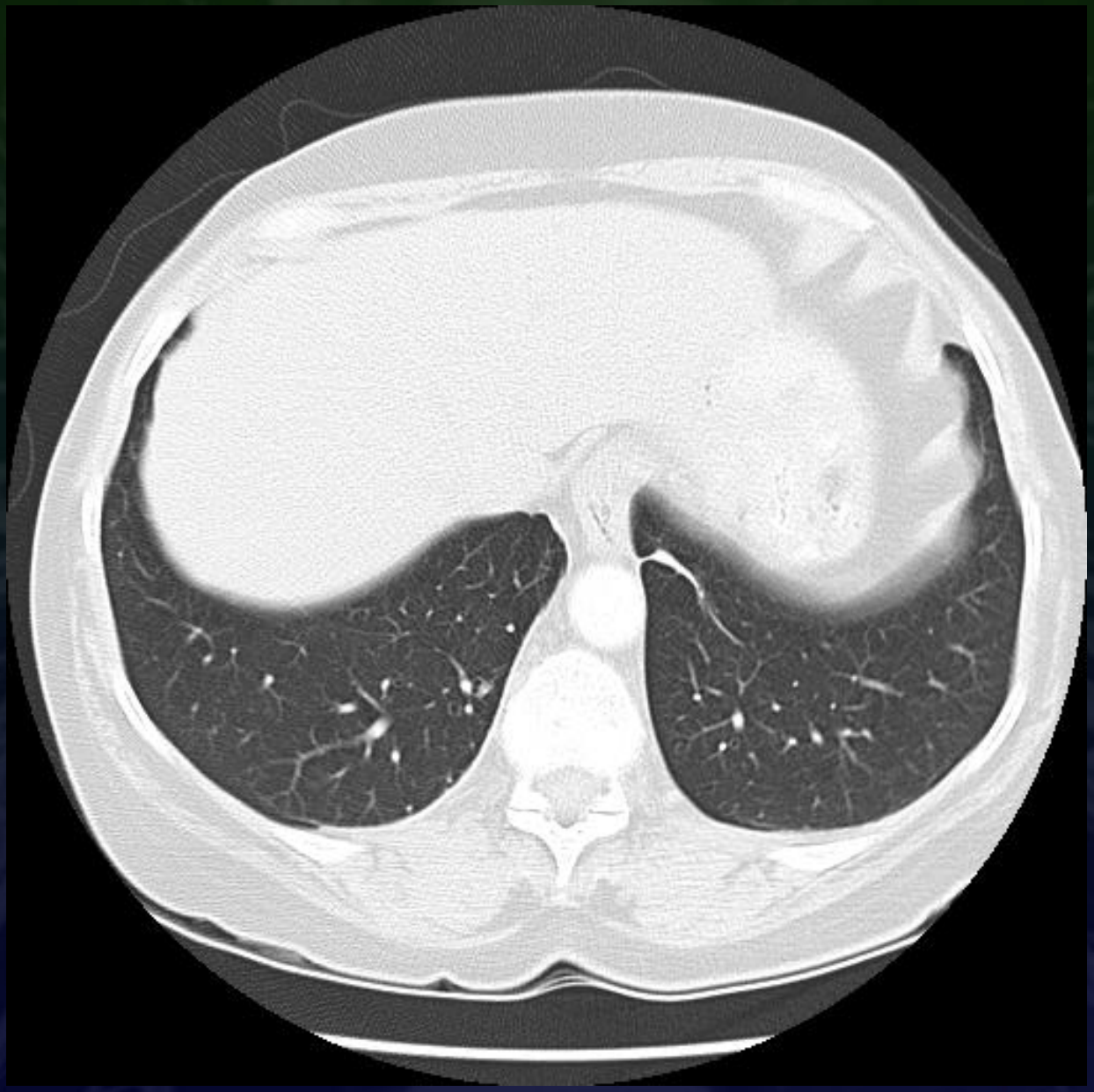
Lingular Segment
Lt Upper Lobe

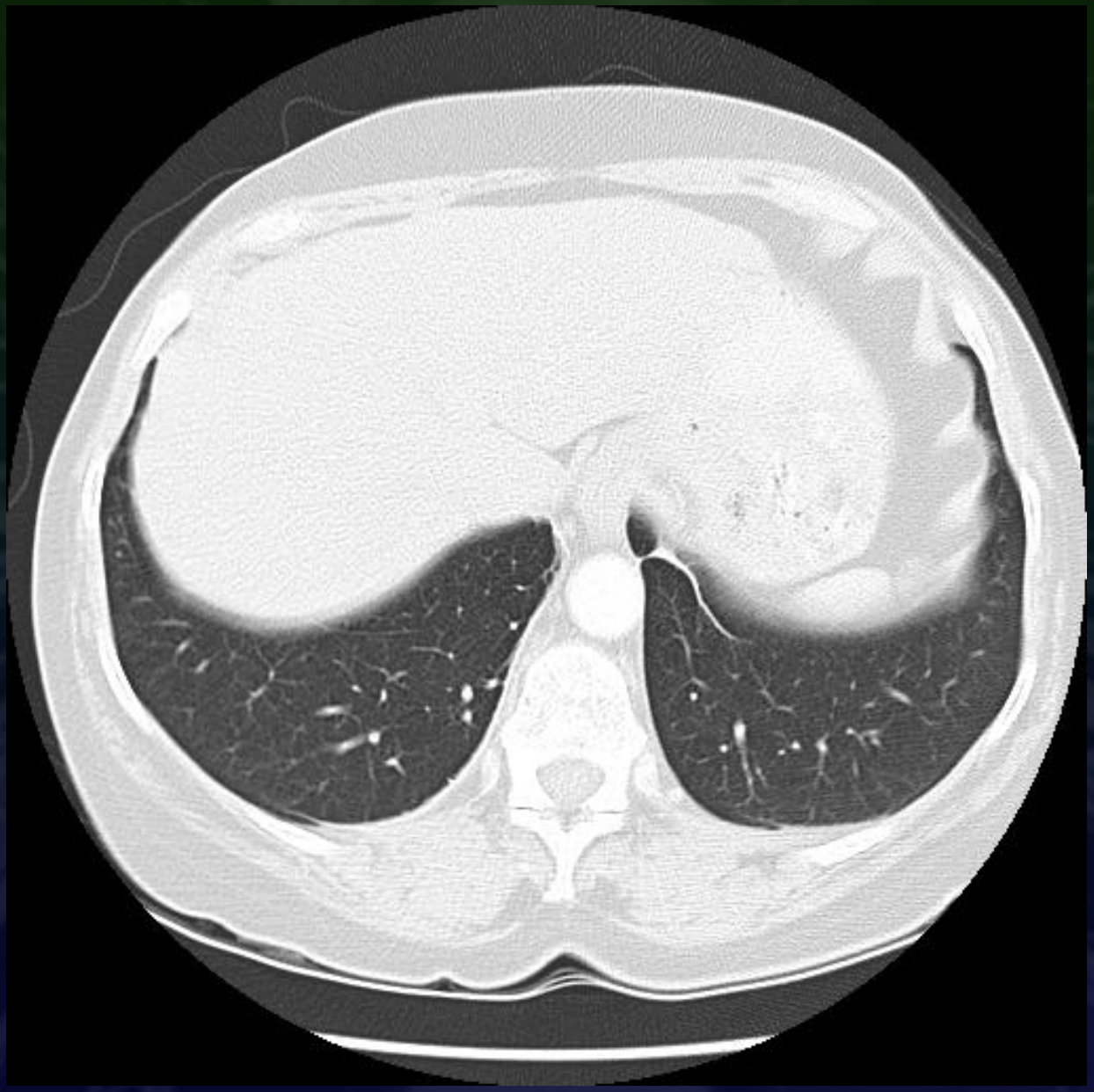


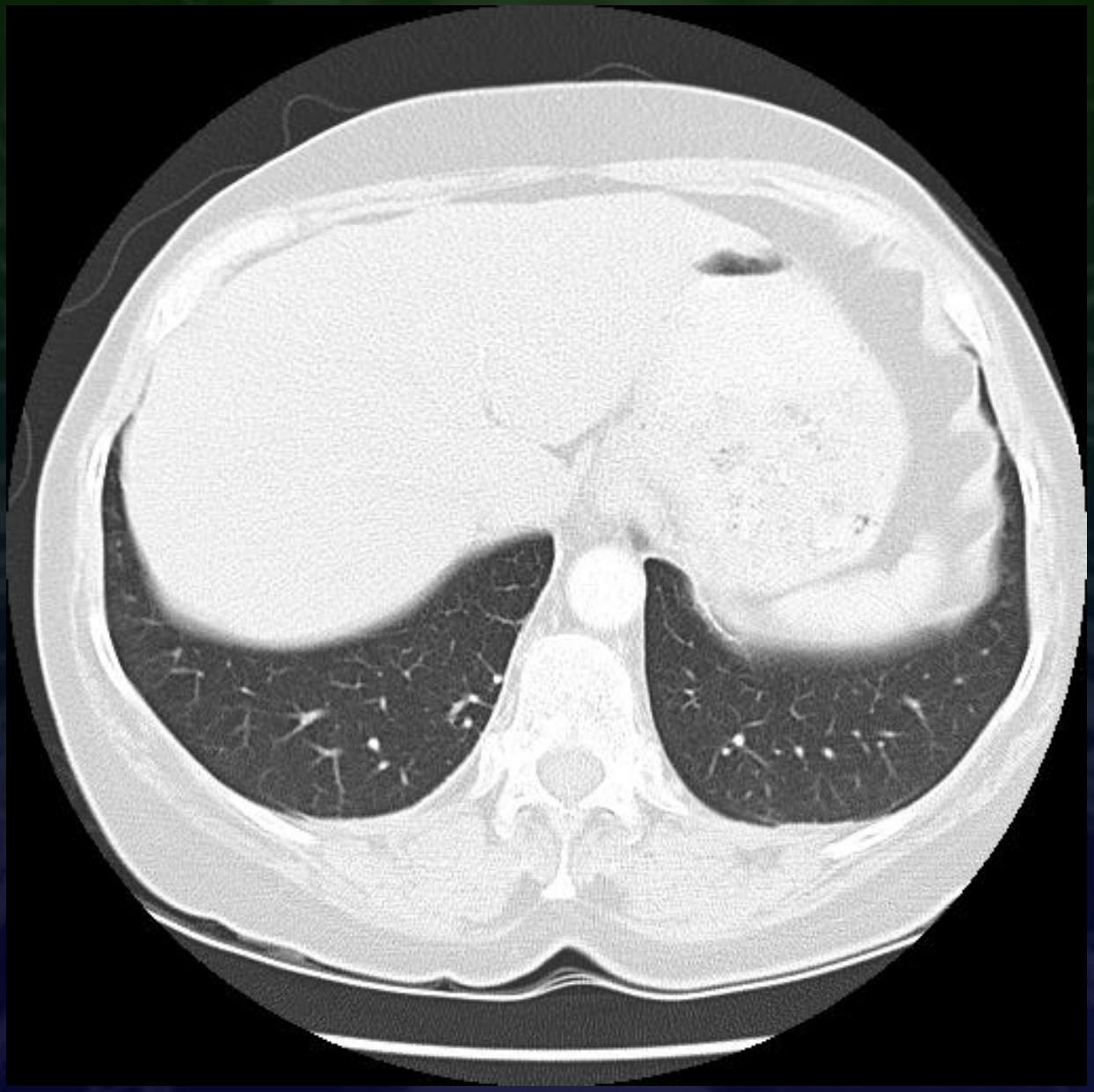


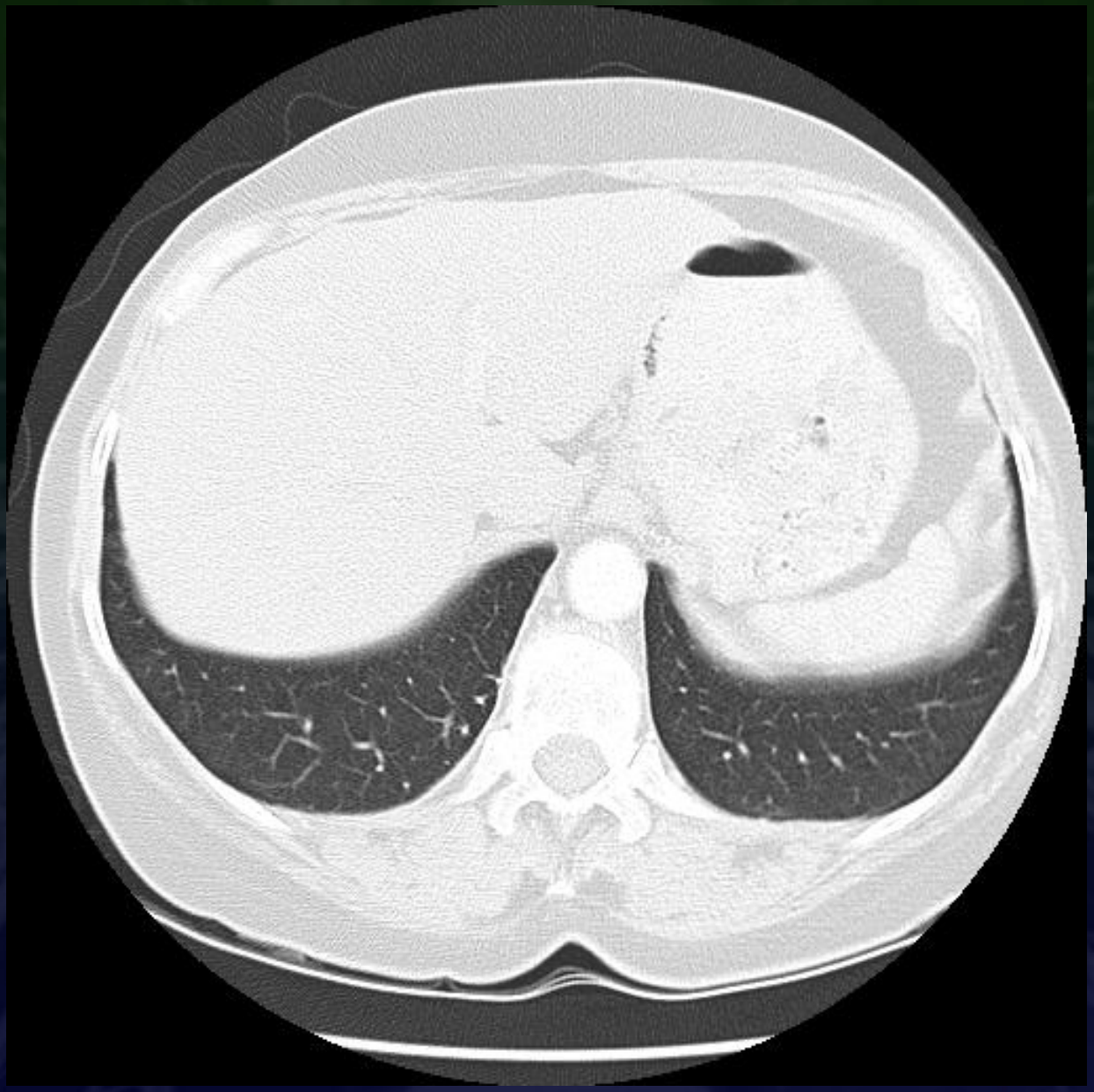


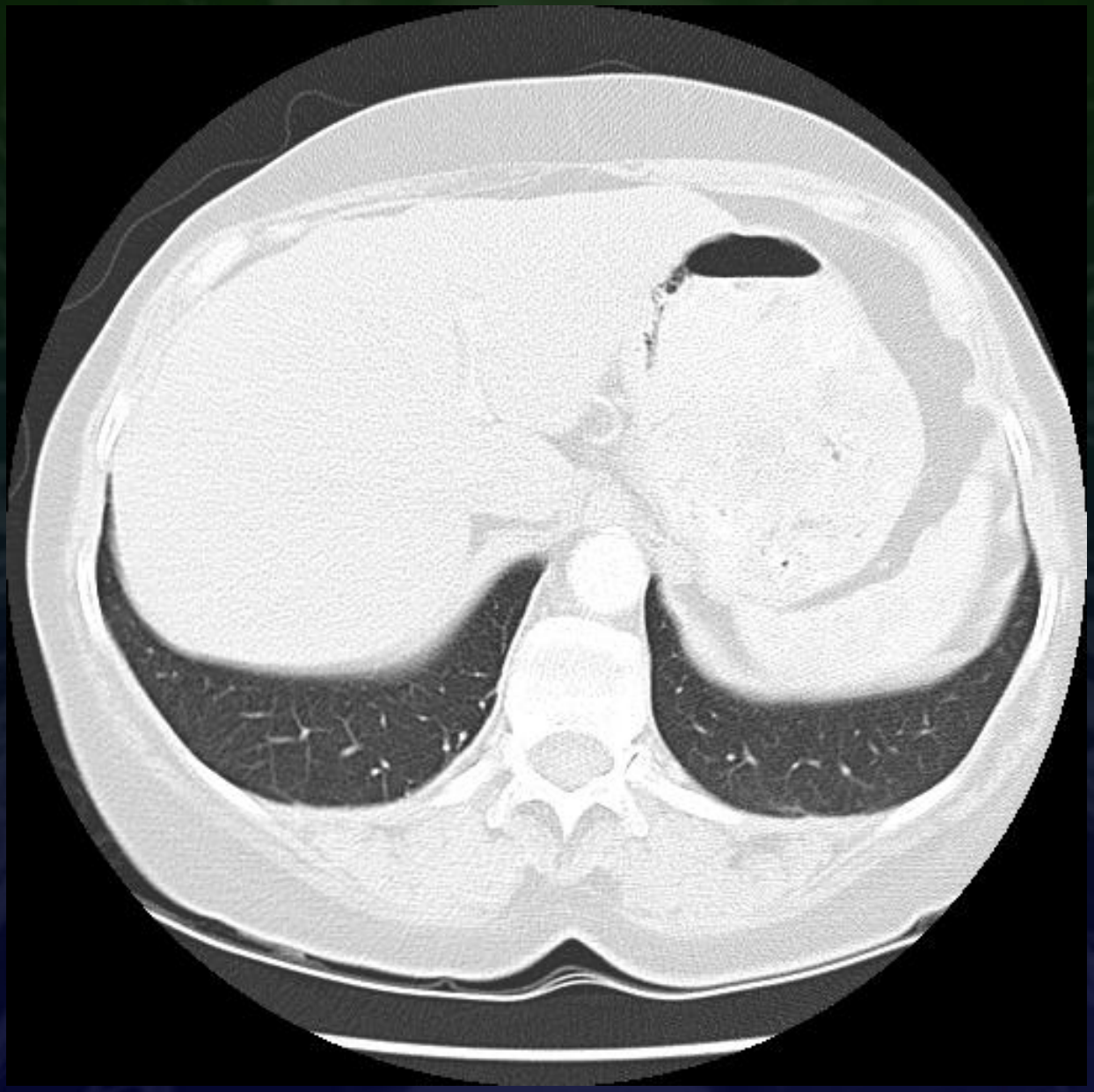

Left Hemidiaphragm

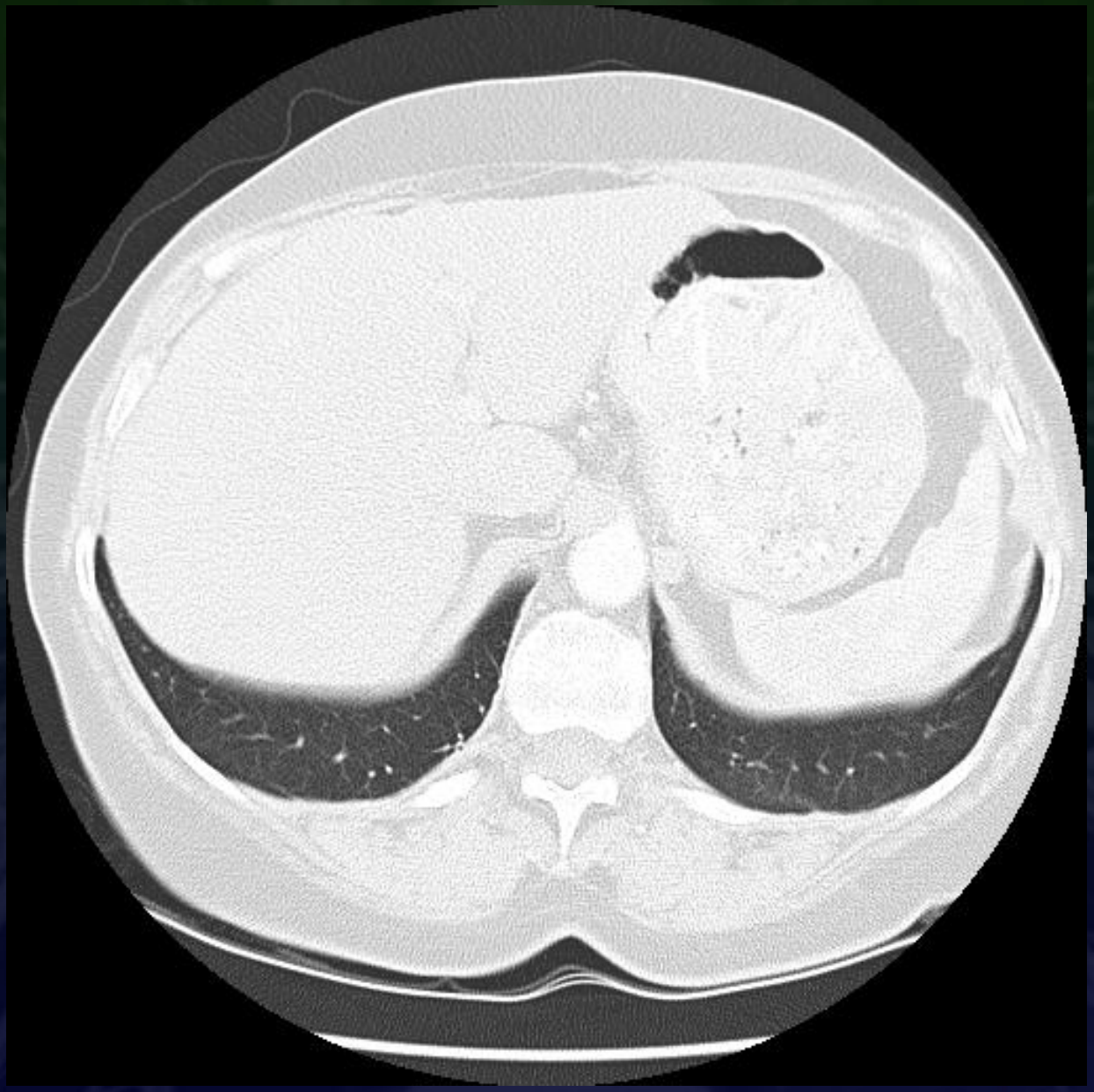


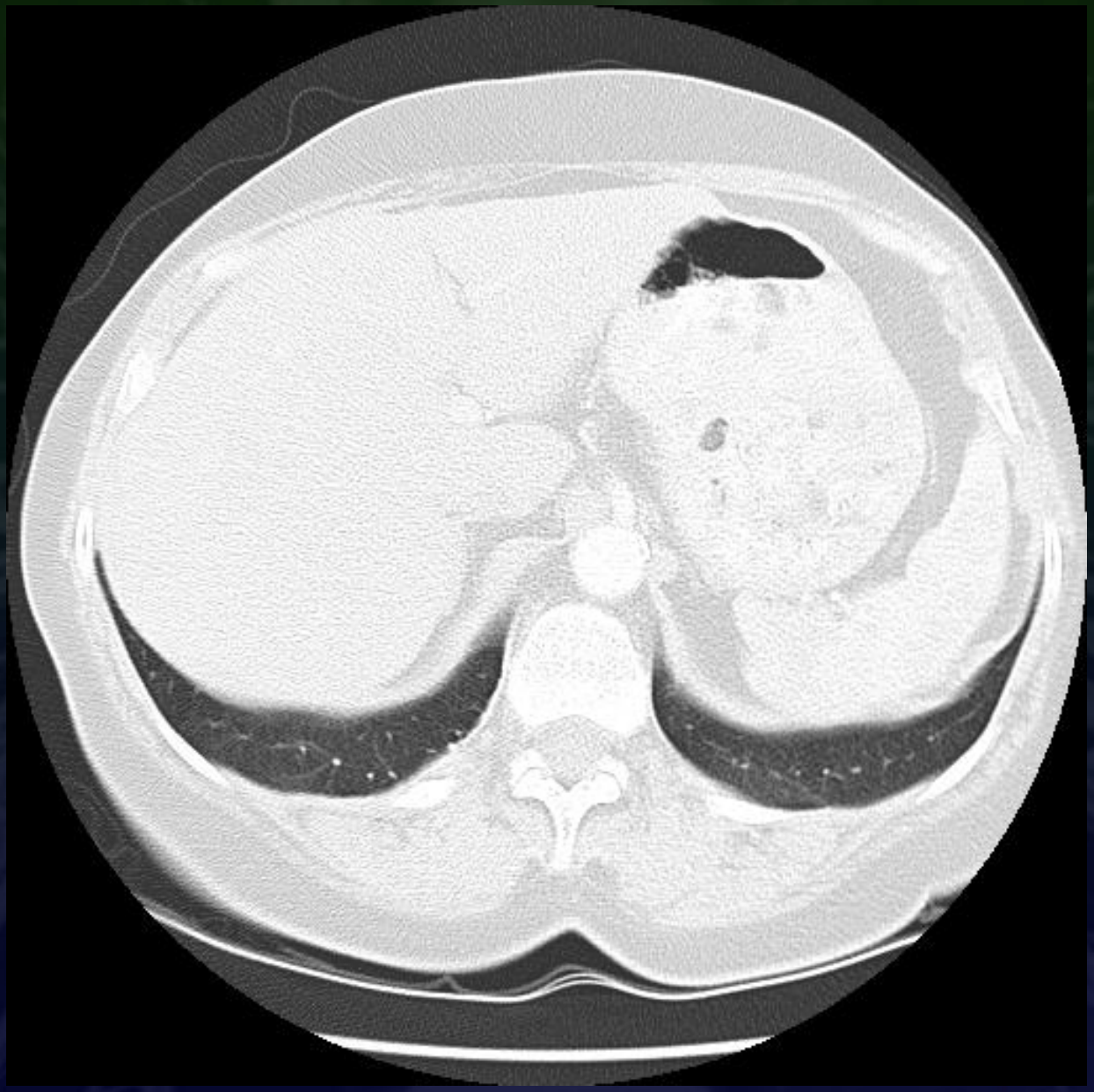


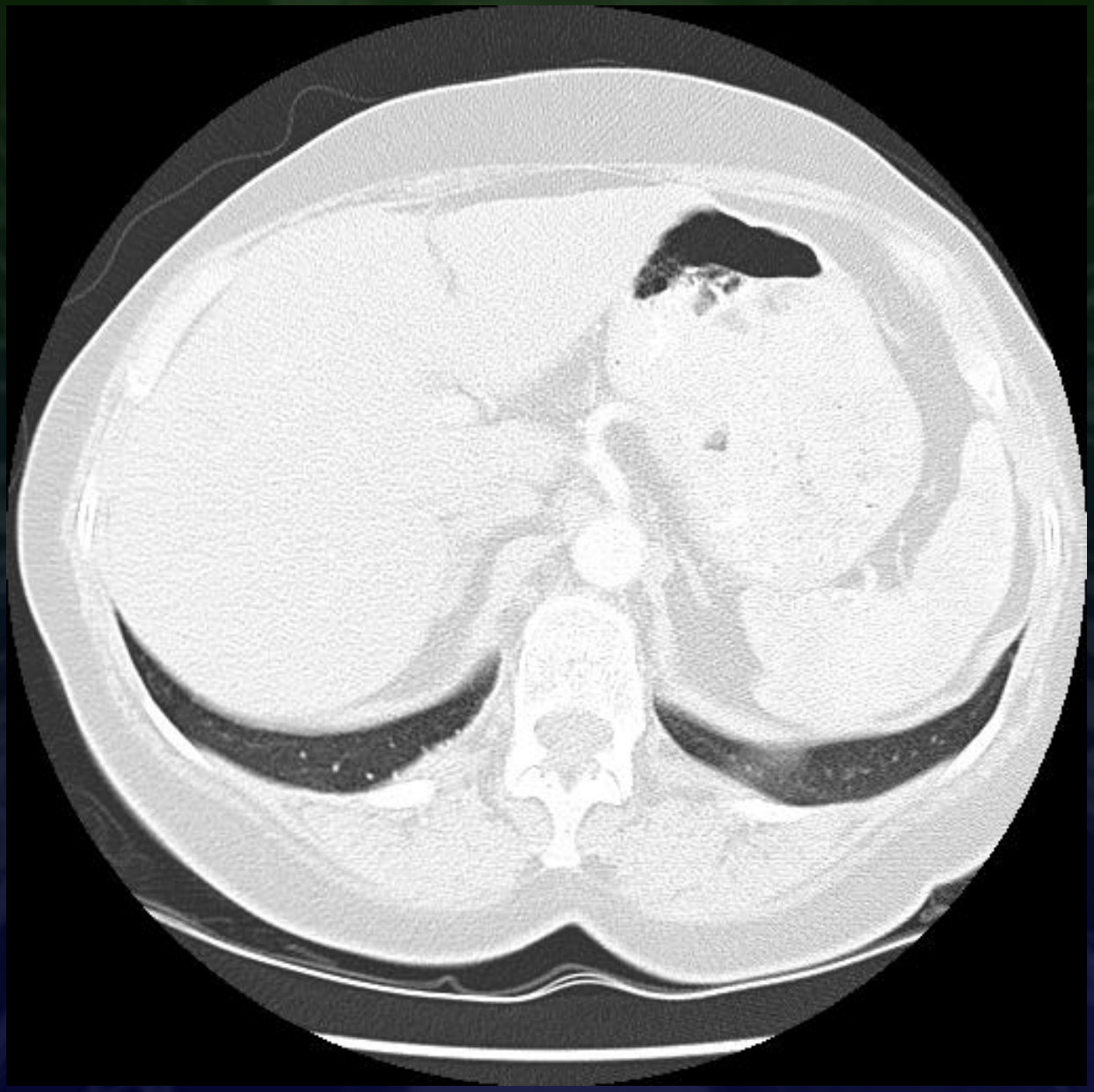




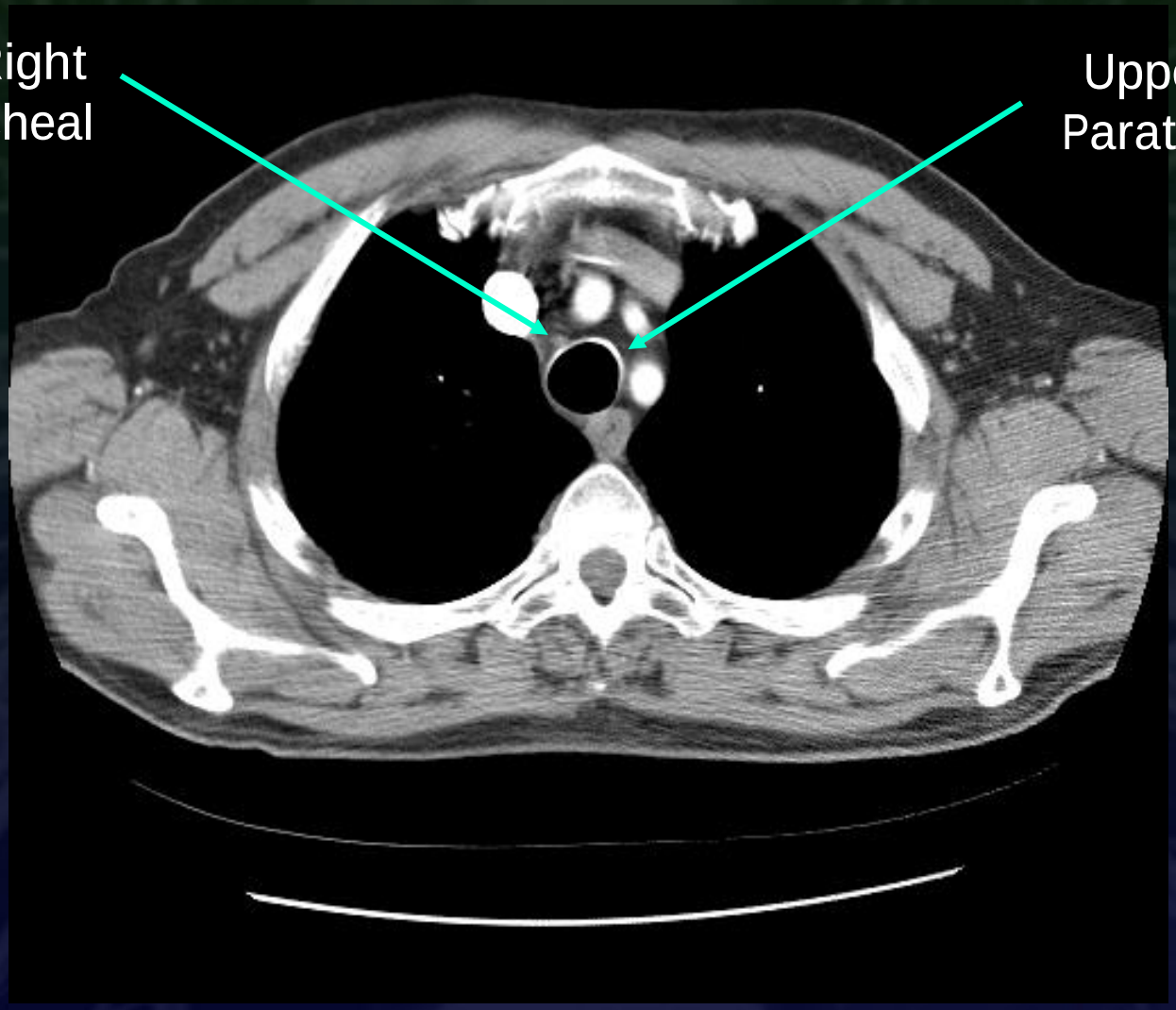




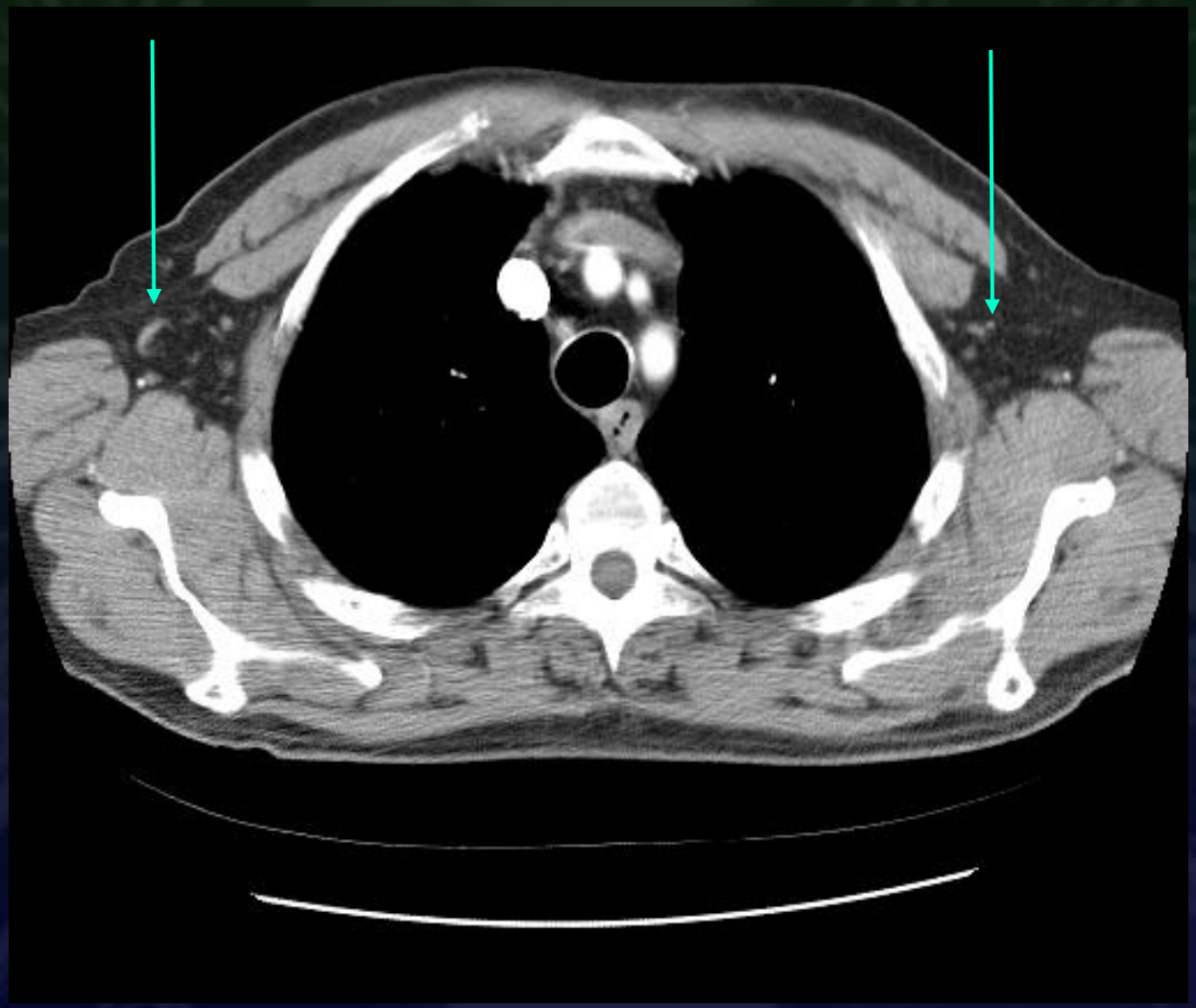


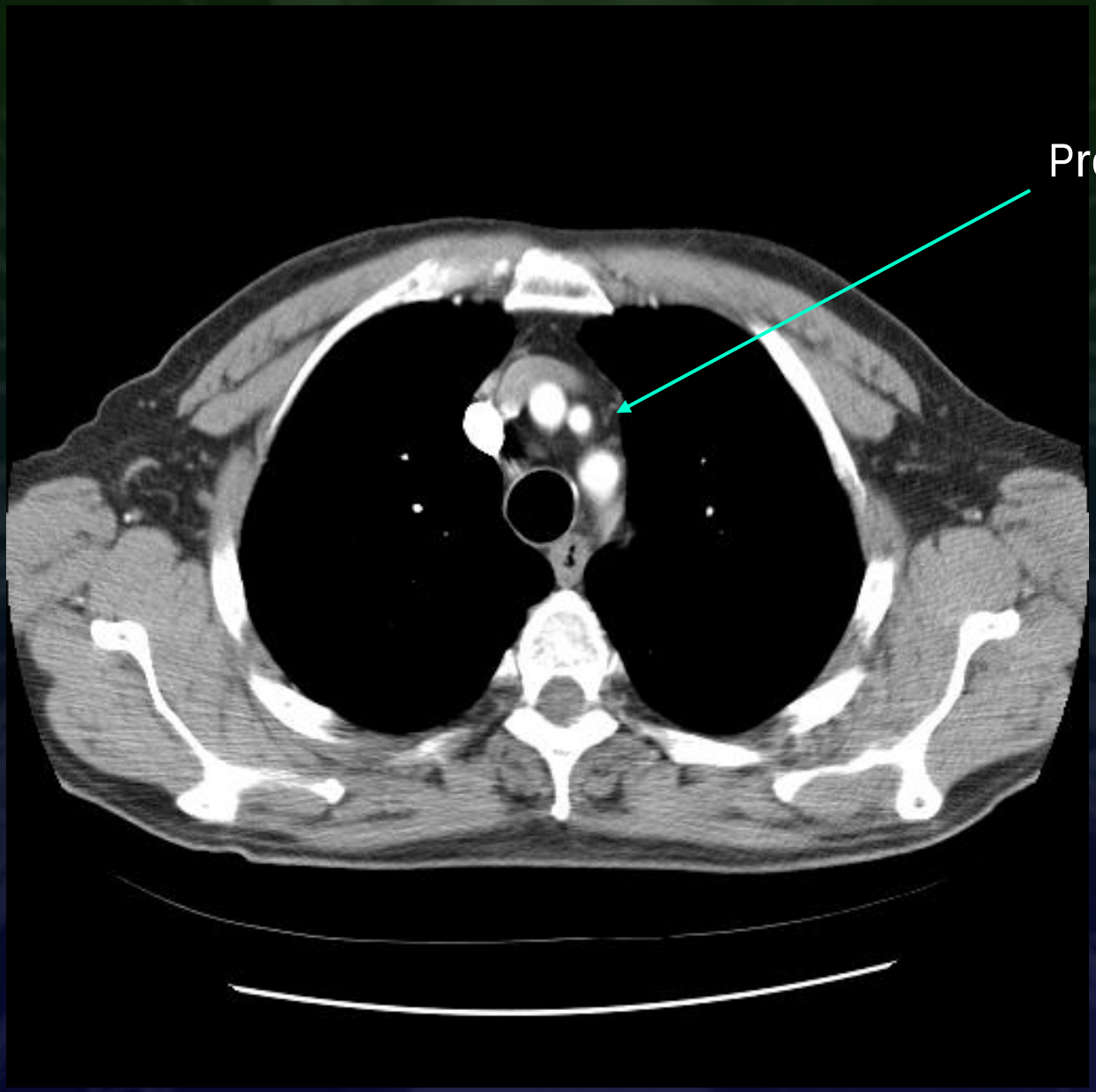


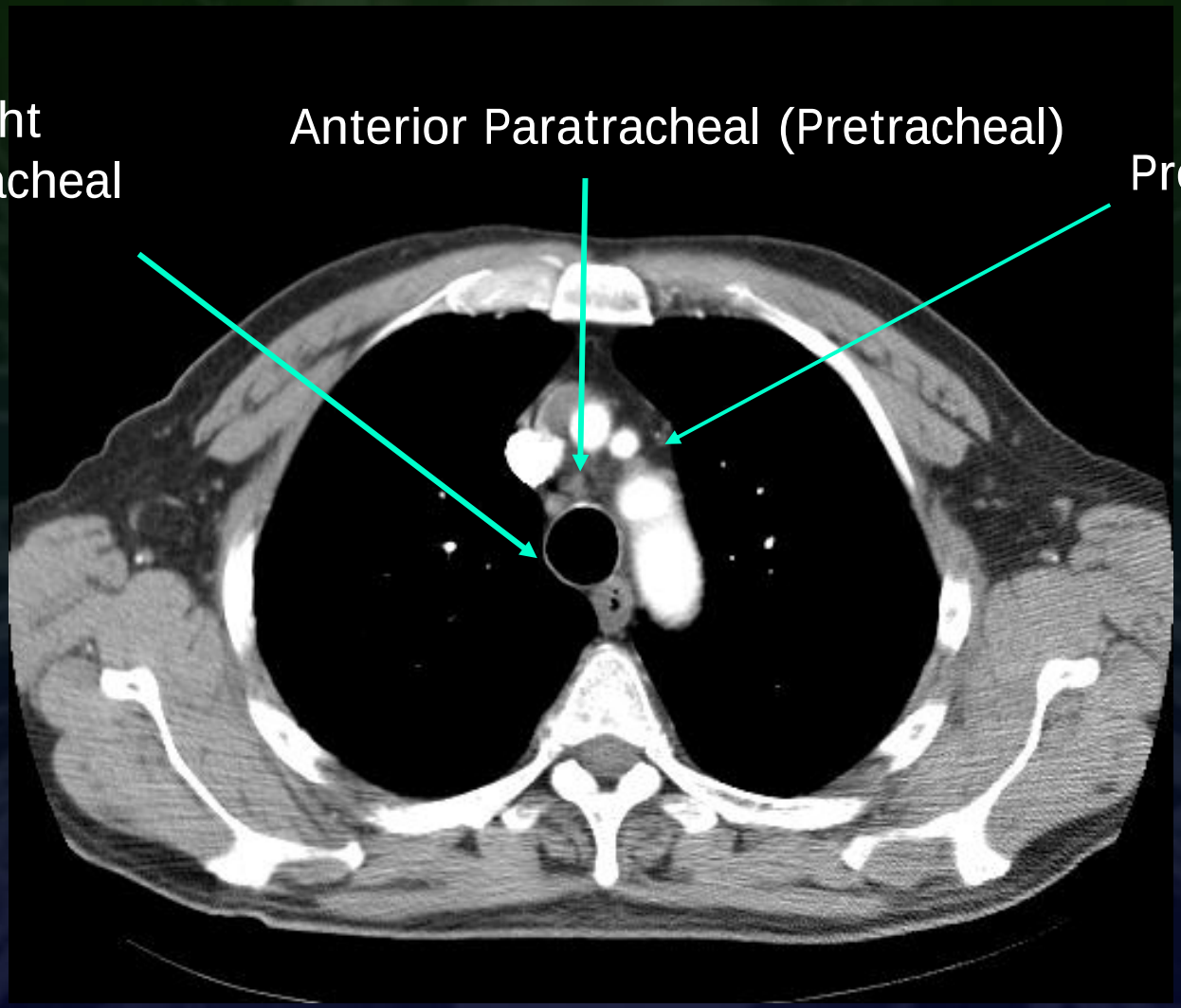
Lymph nodes: location of major groups

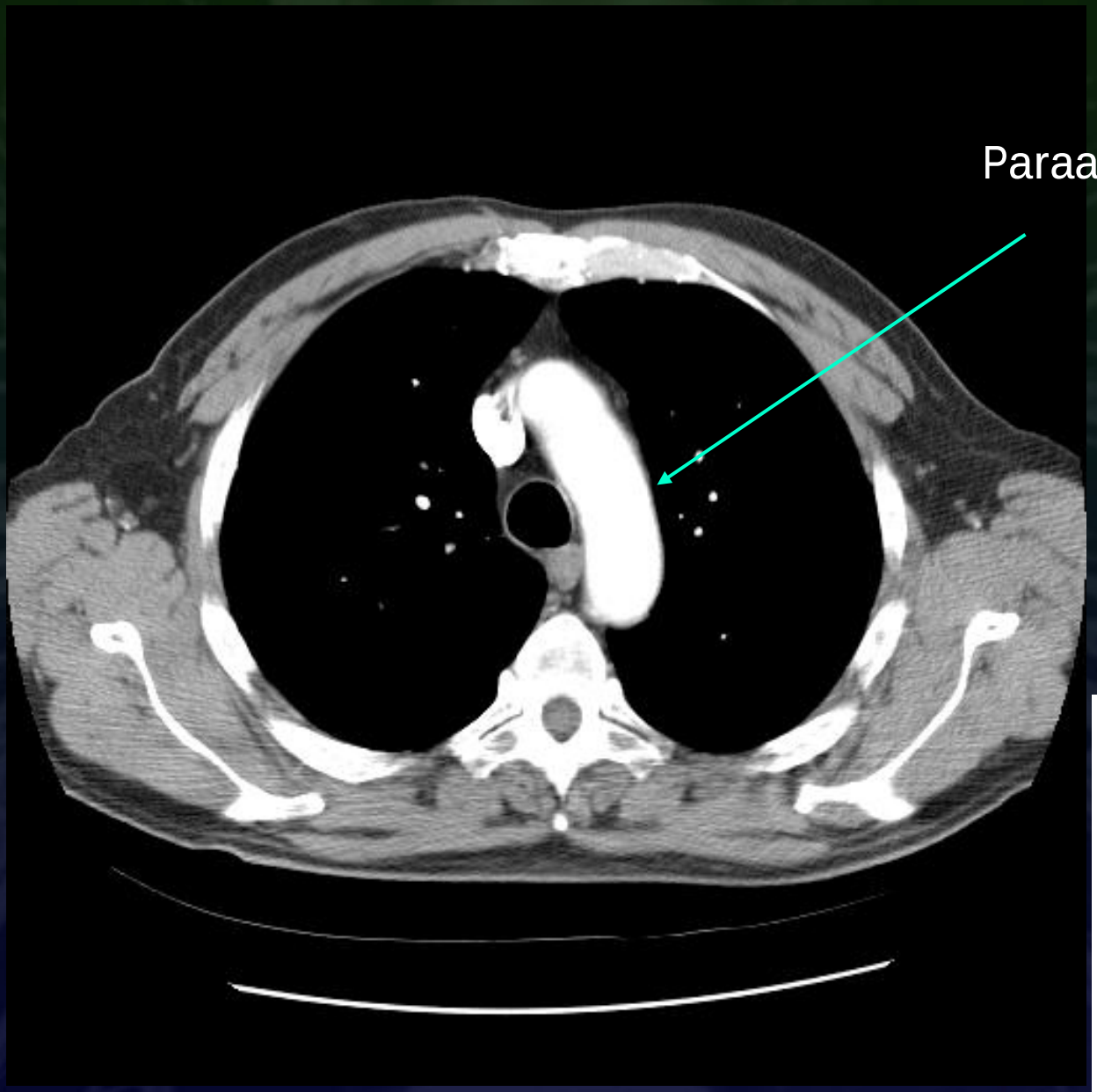


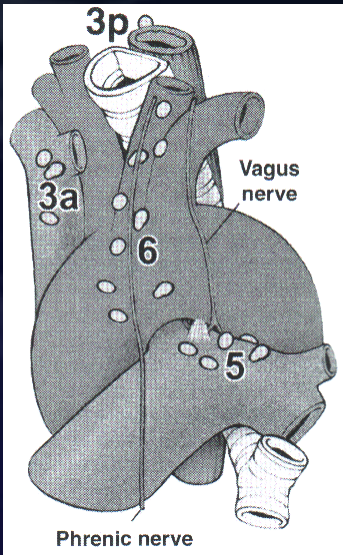
Axillary

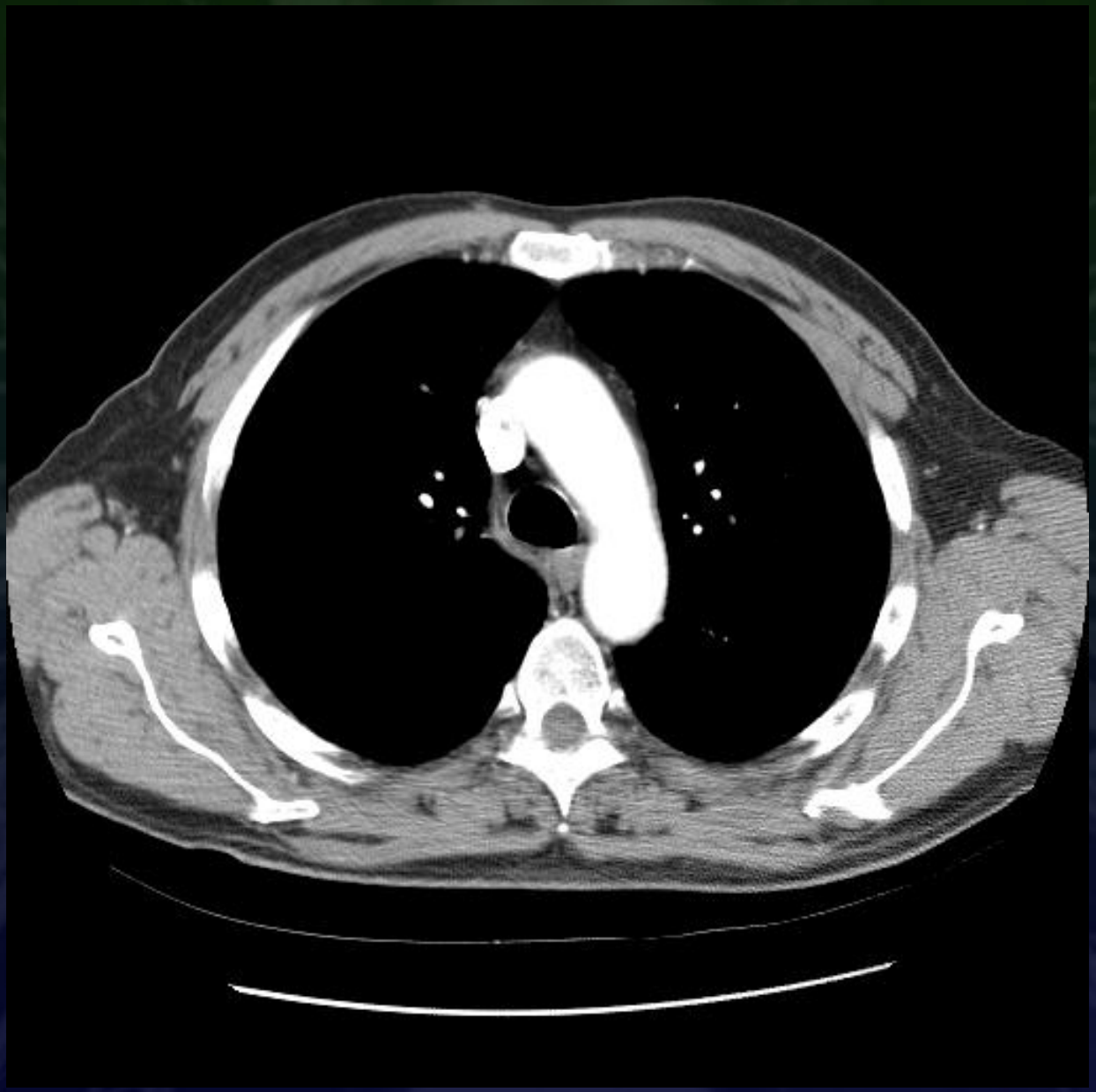


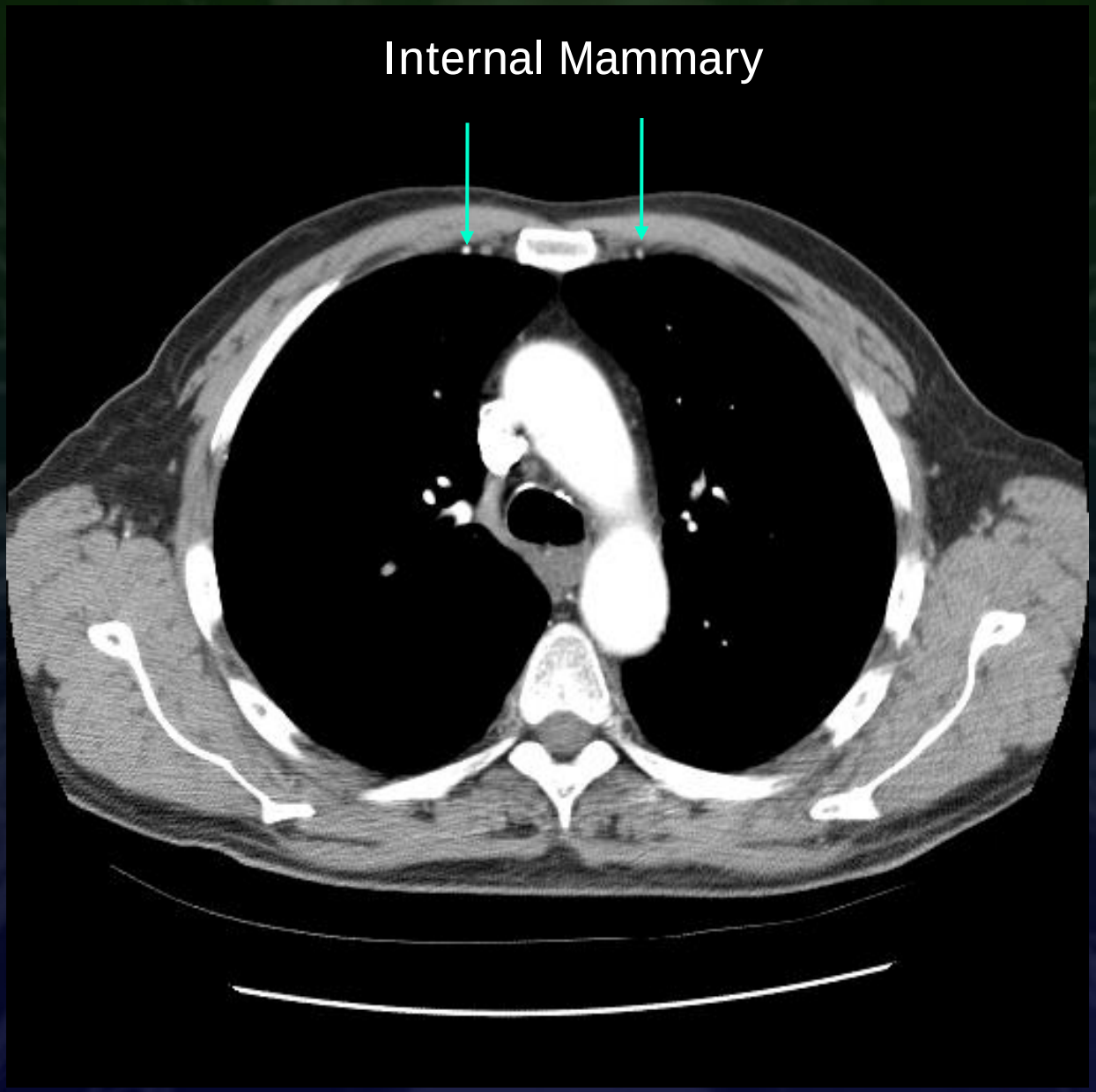

Prevascular

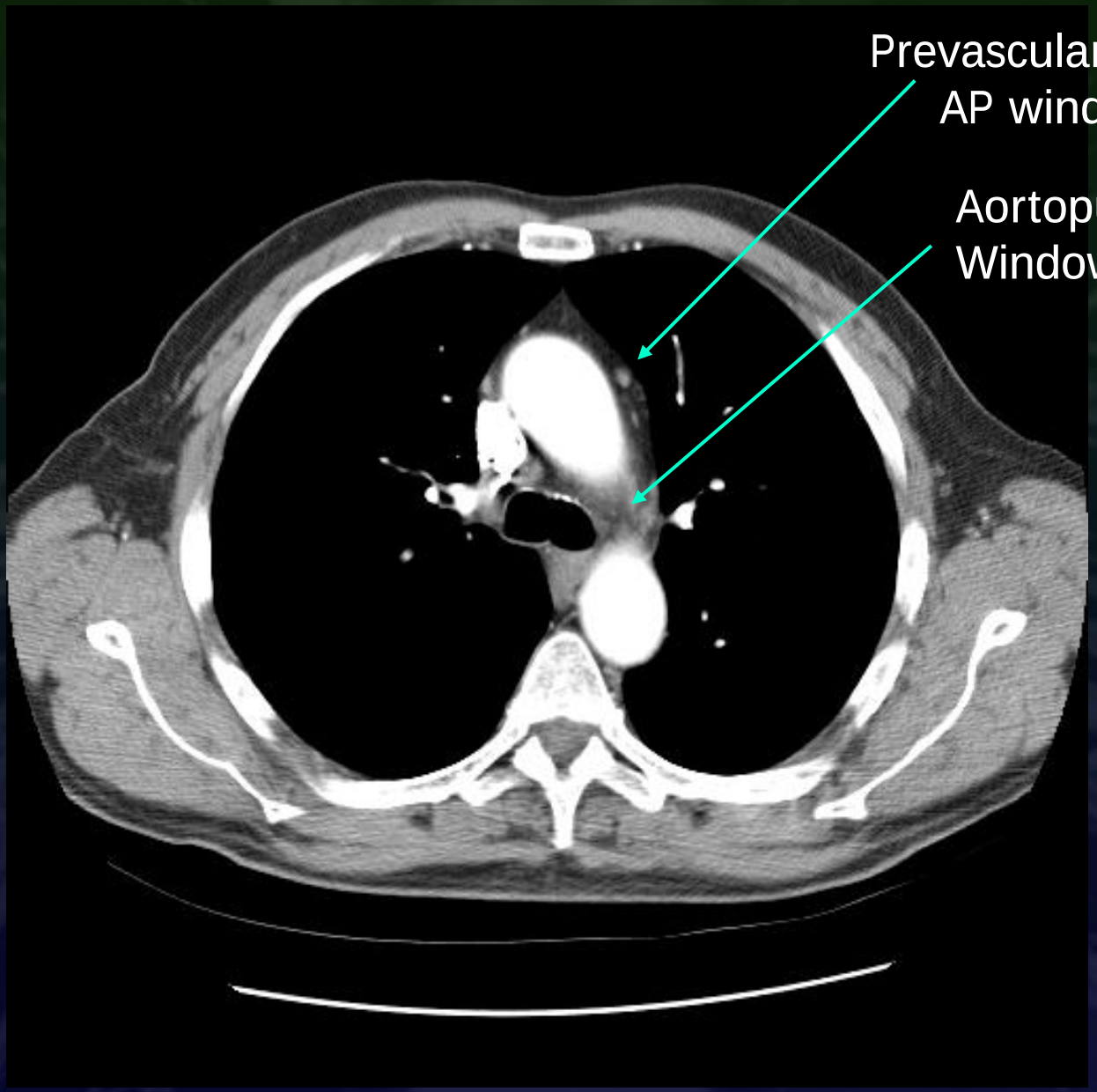

Right
Paratracheal
Anterior Paratracheal (Pretracheal)
Prevascular

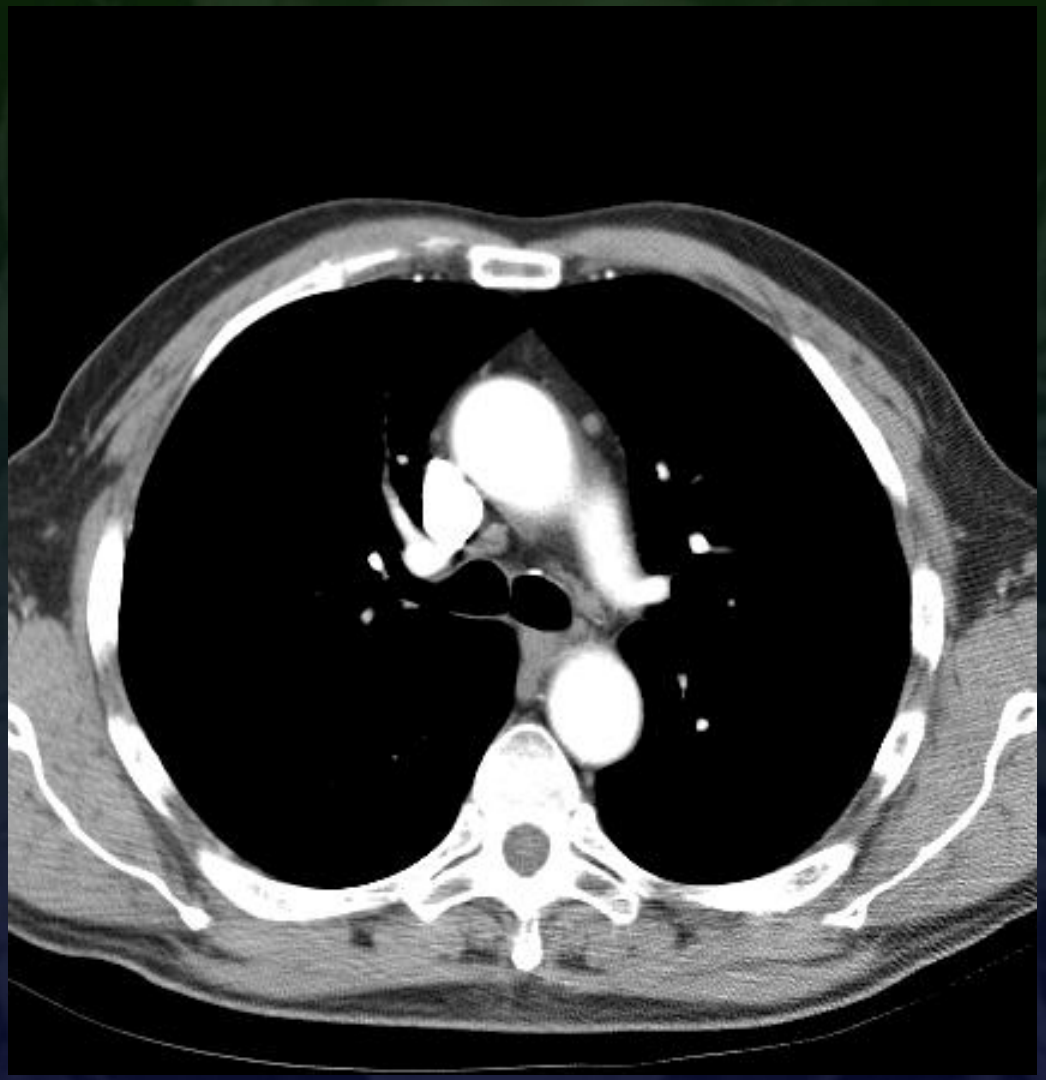

Paraaortic

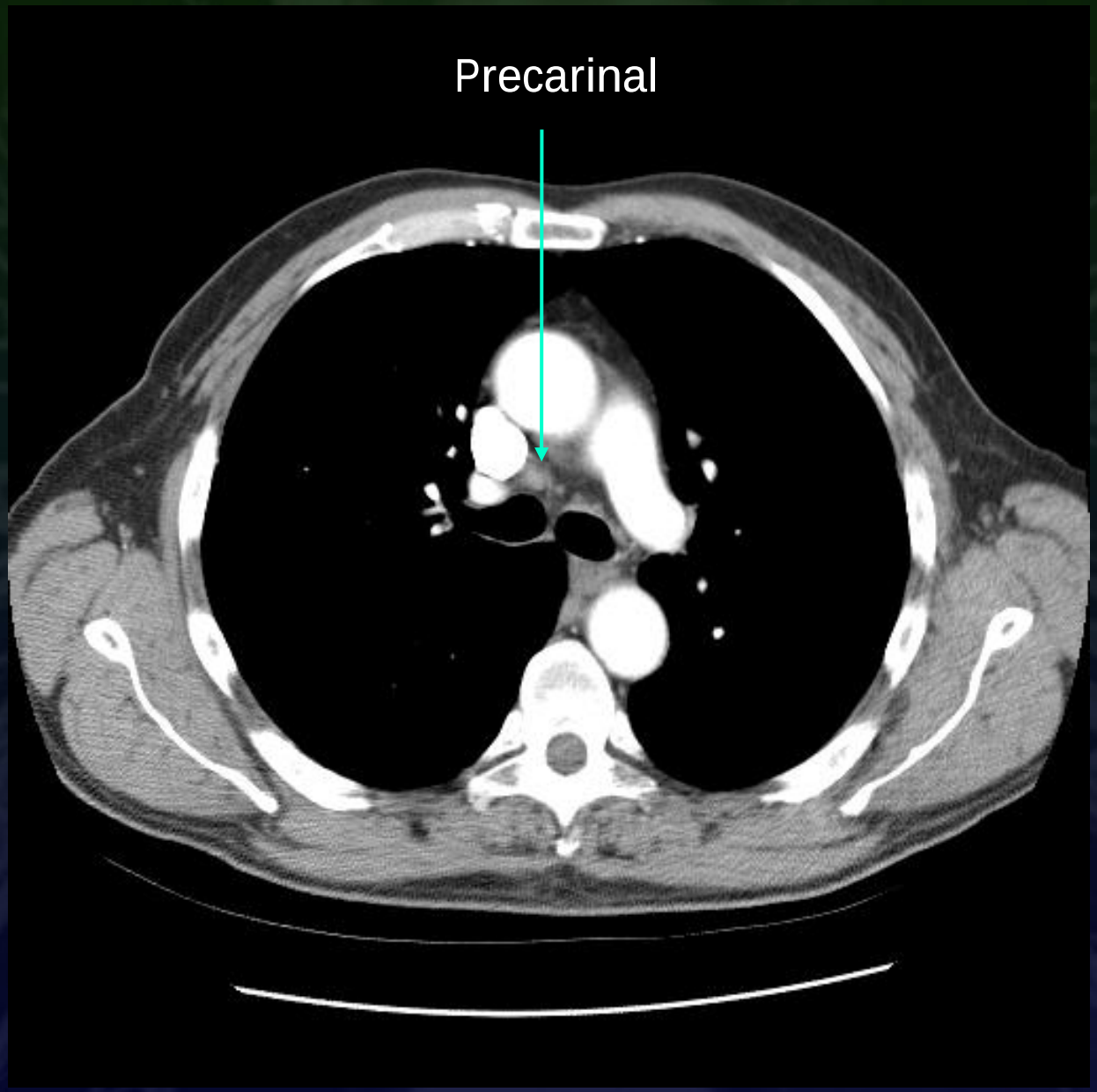

3p
3a
Vagus nerve
6
5
Phrenic nerve

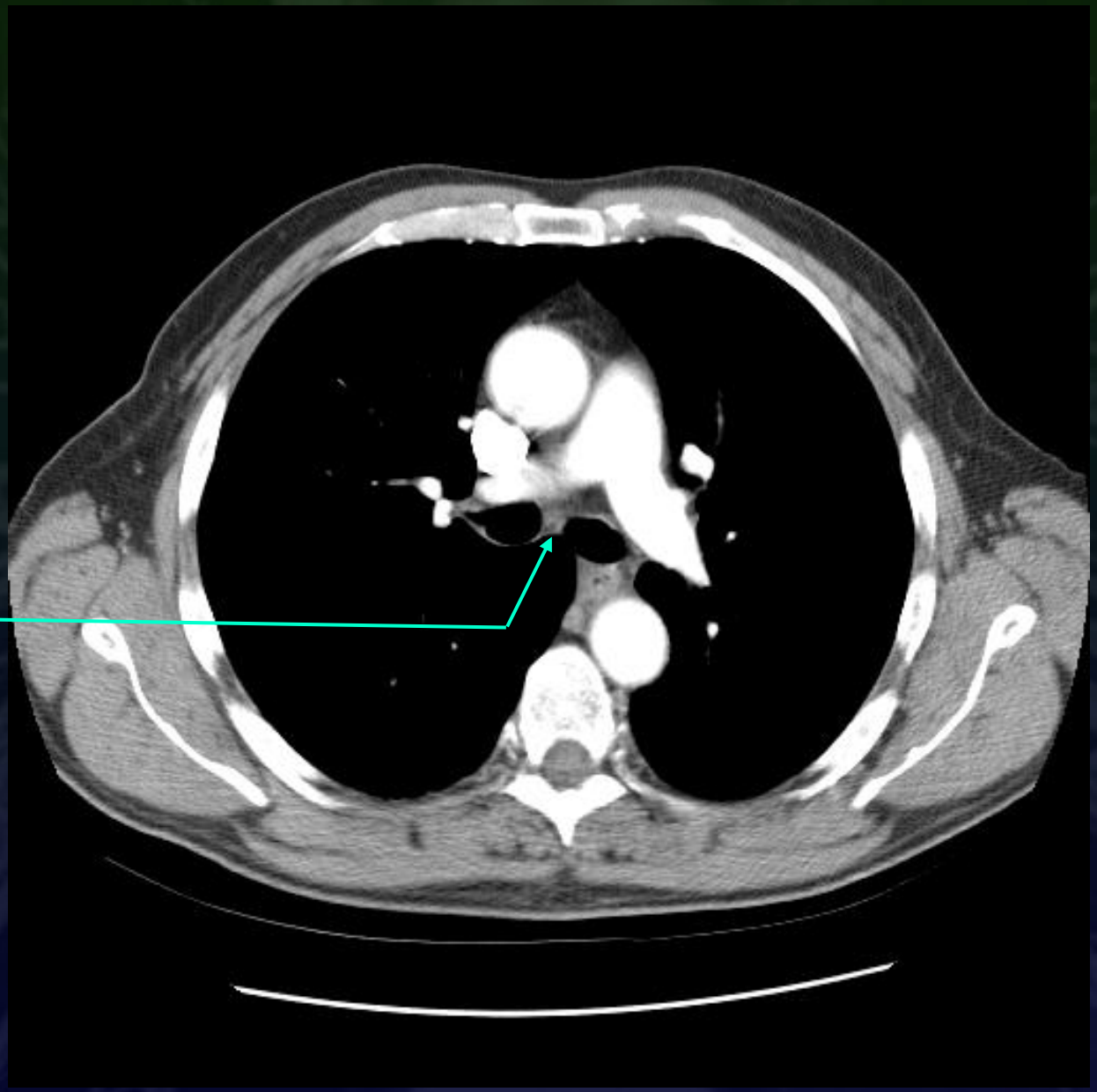


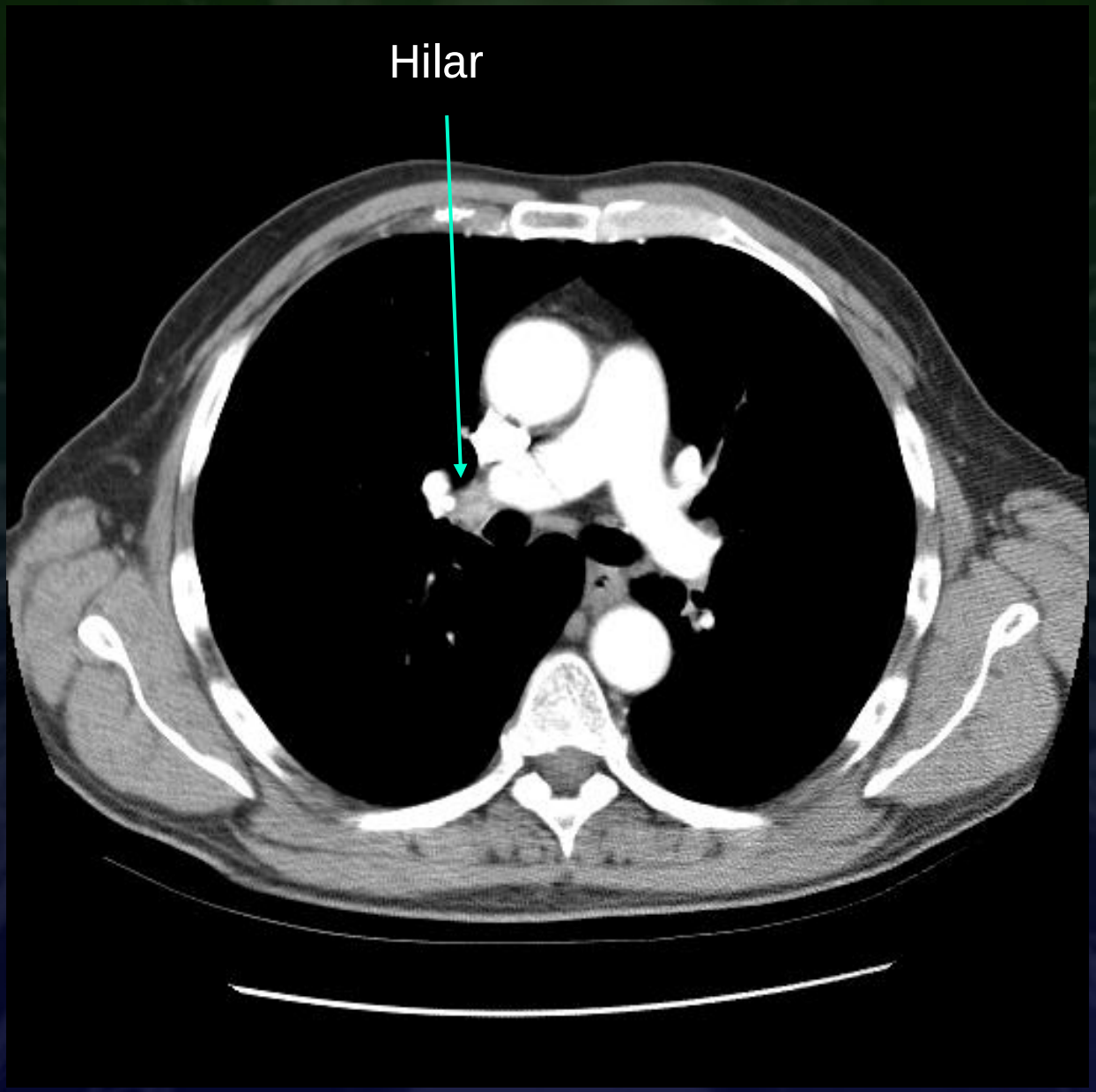

Internal Mammary

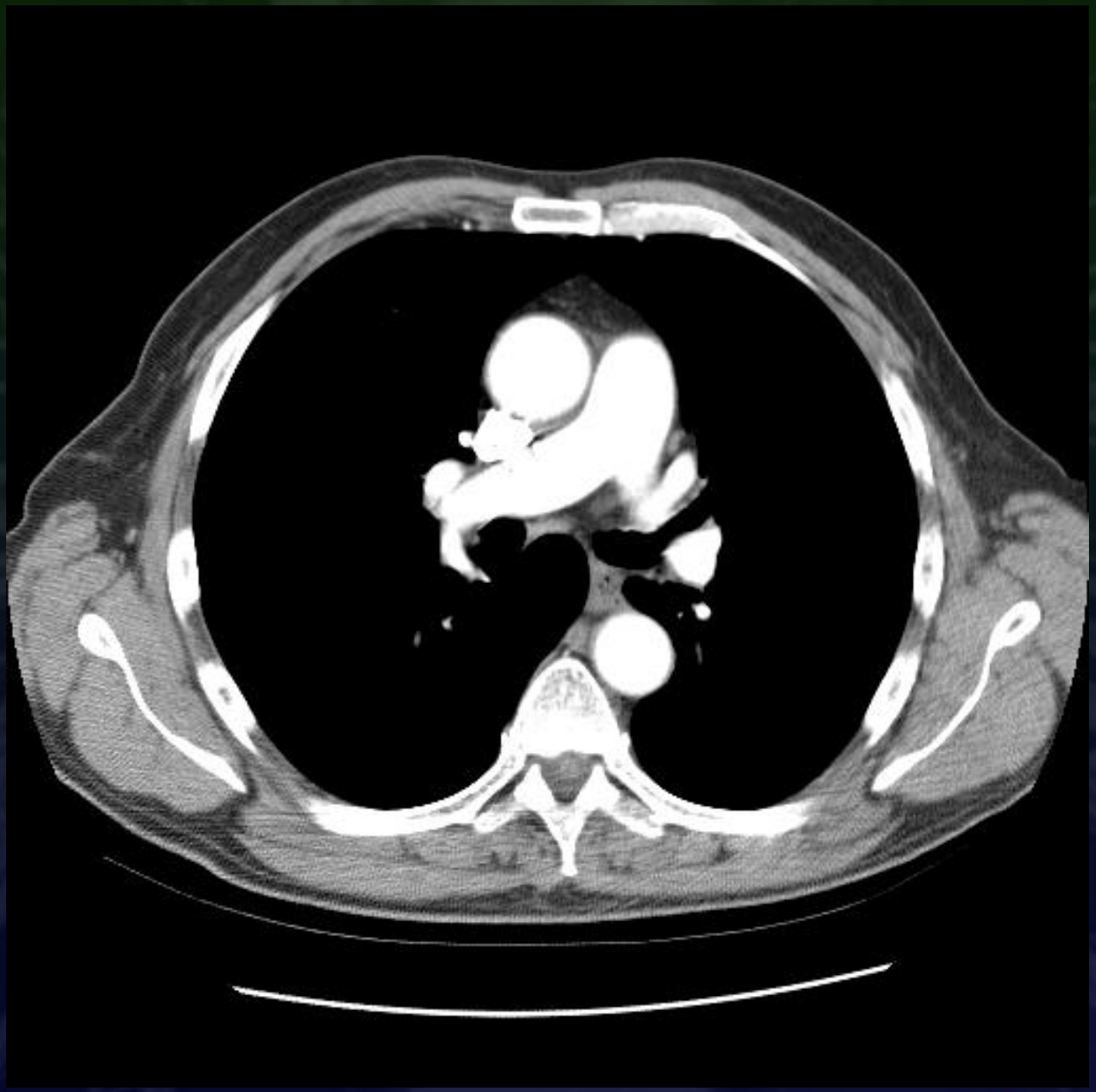

Prevascular (?) or
AP window
Aortopulmonary
Window



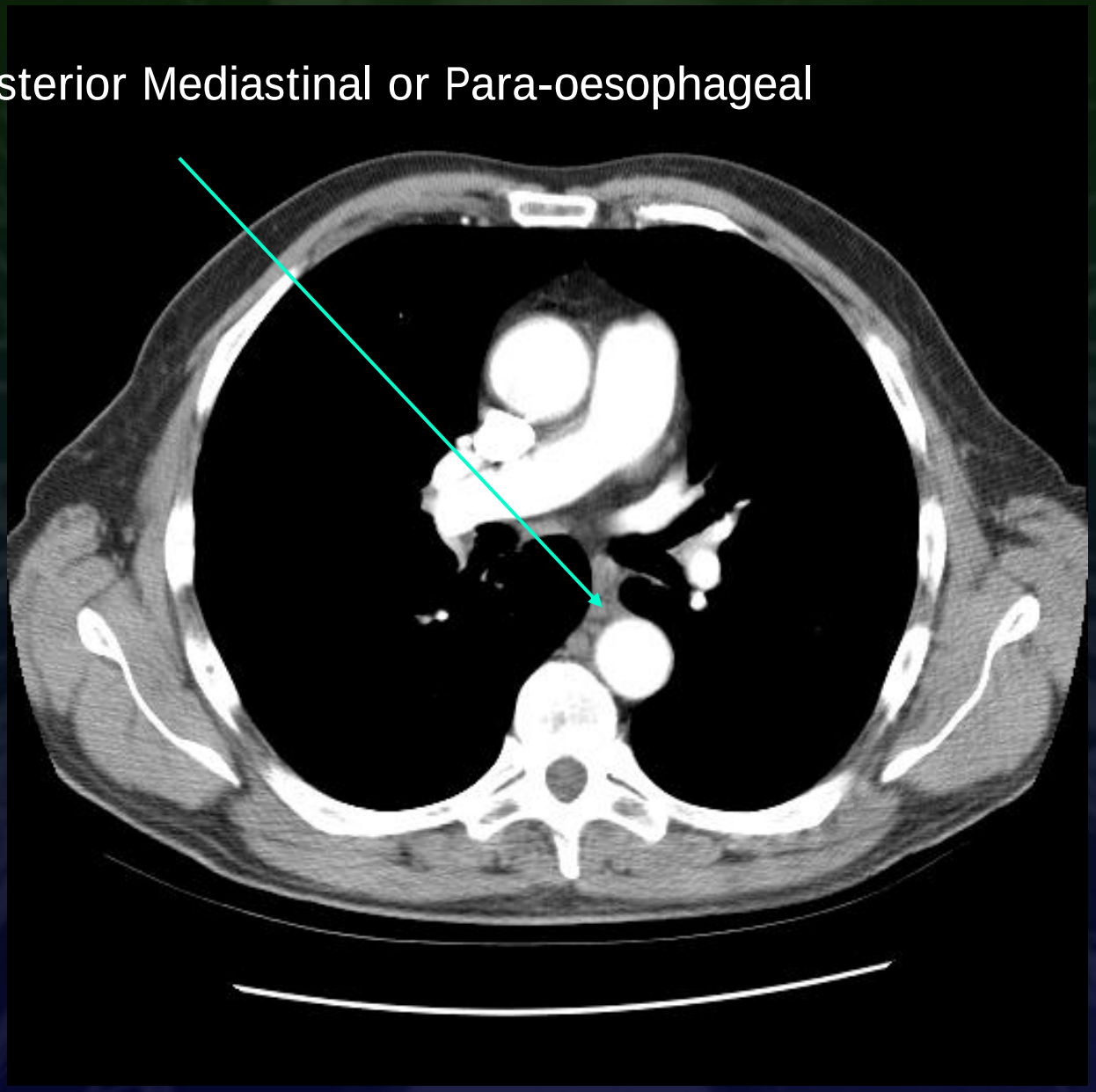

Precarinal

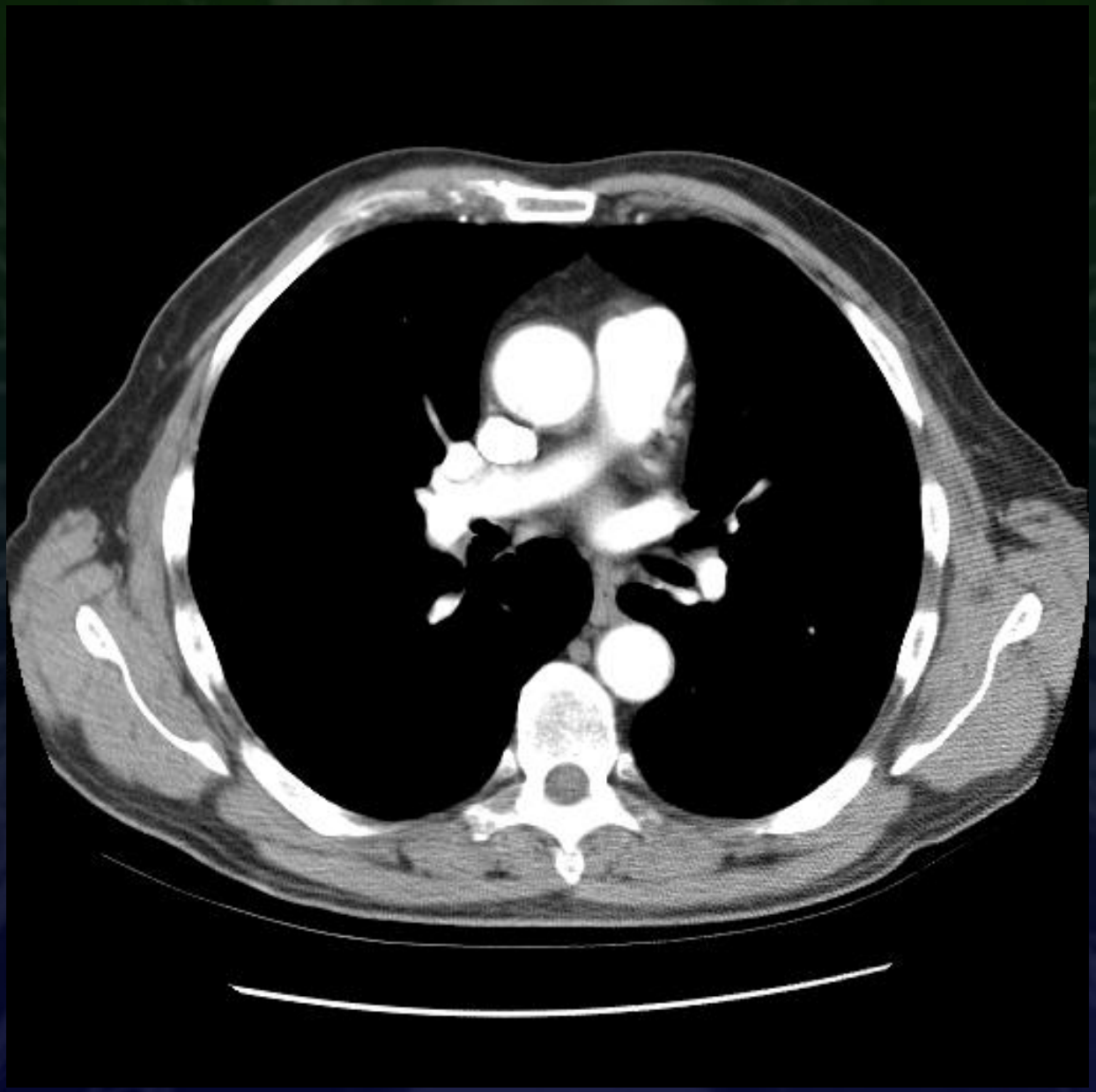

Subcarinal


Hilar

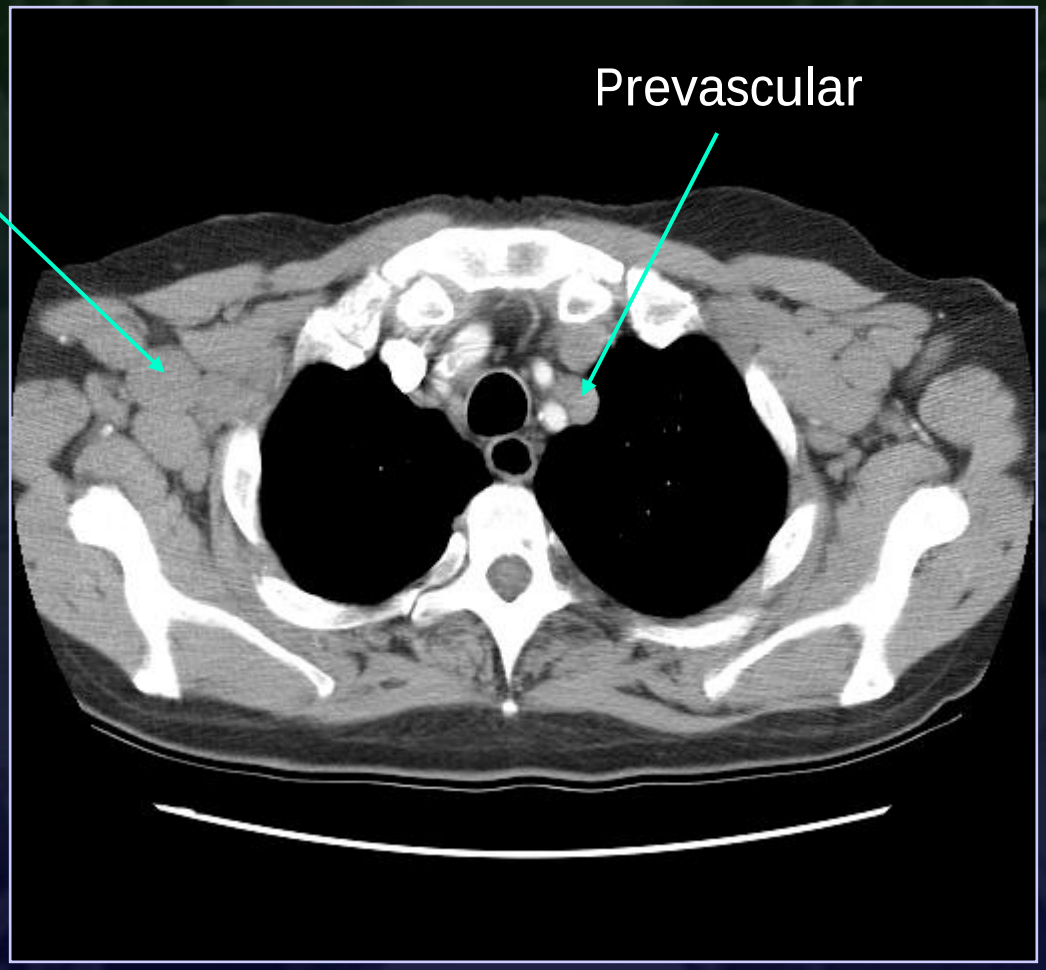


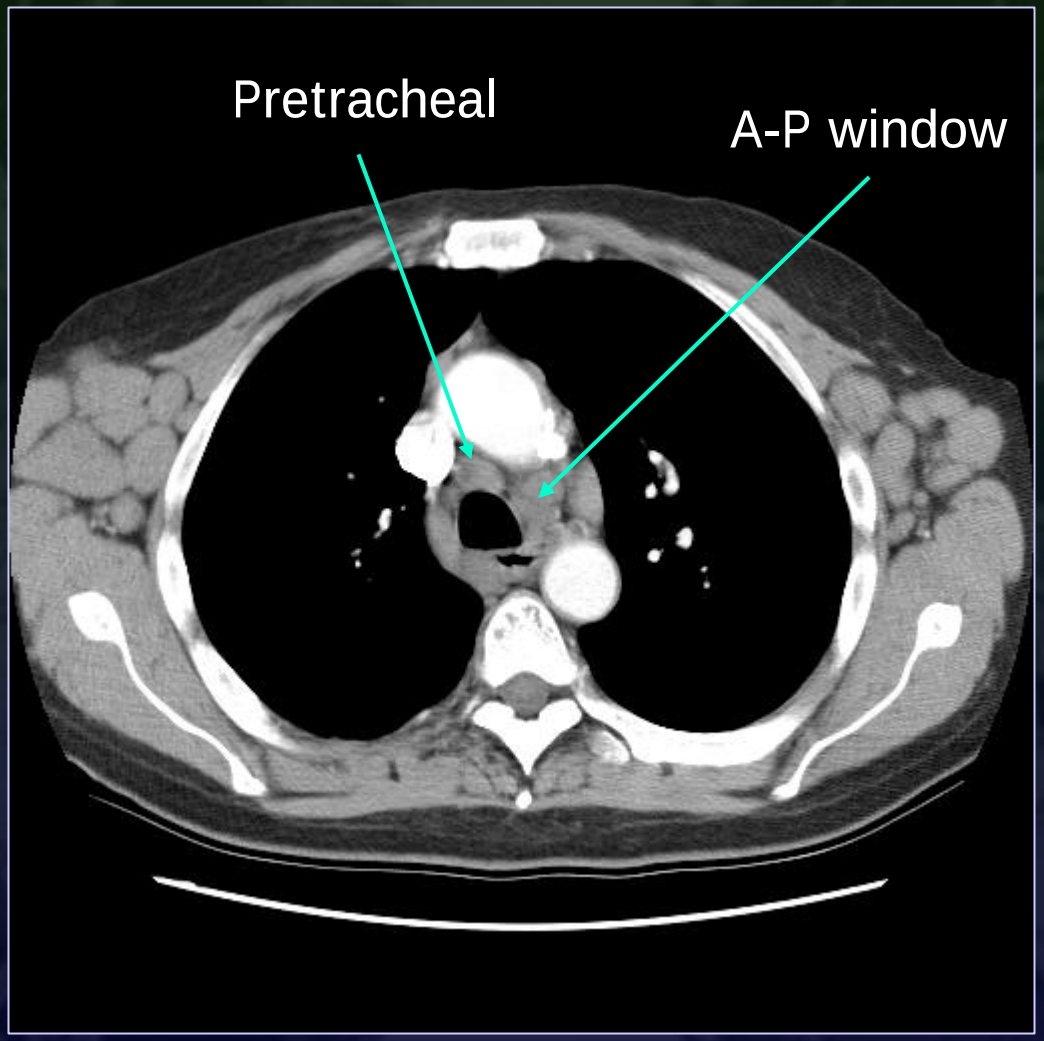
Posterior Mediastinal or Para-oesophageal



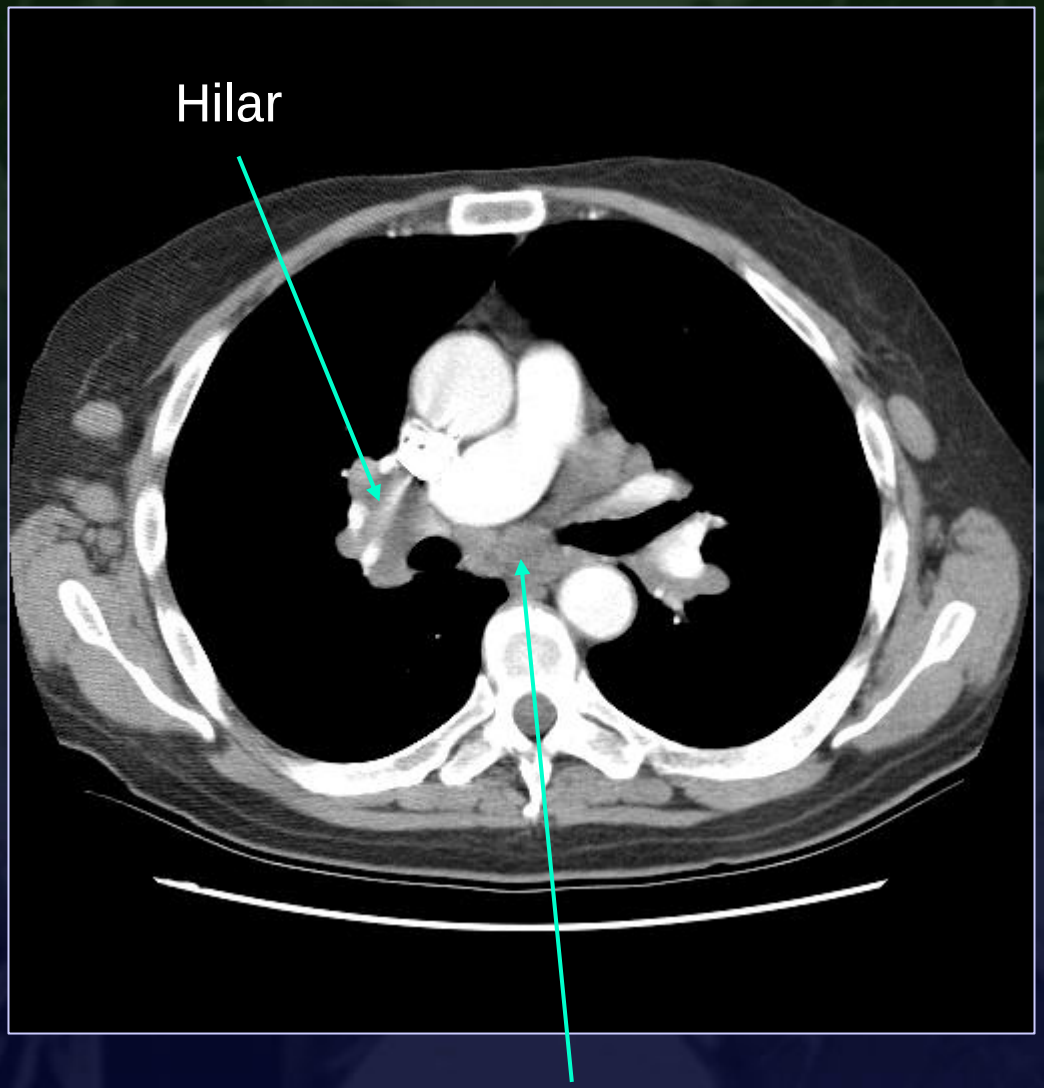


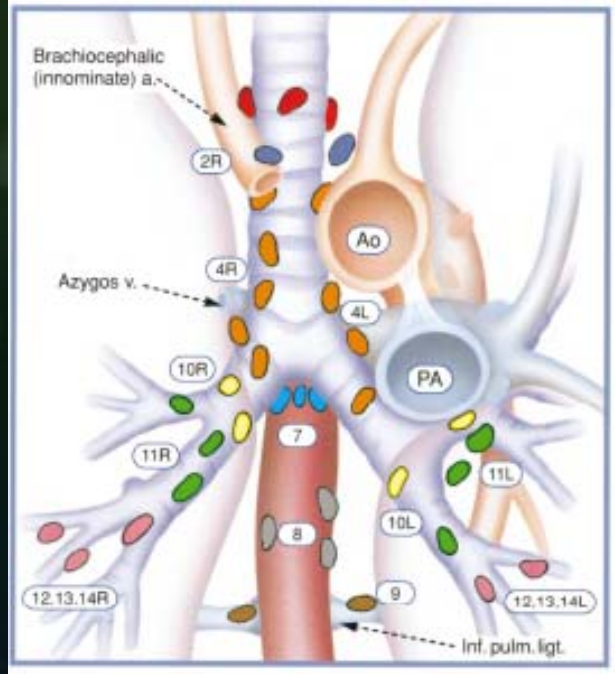
Lymphadenopathy - Example

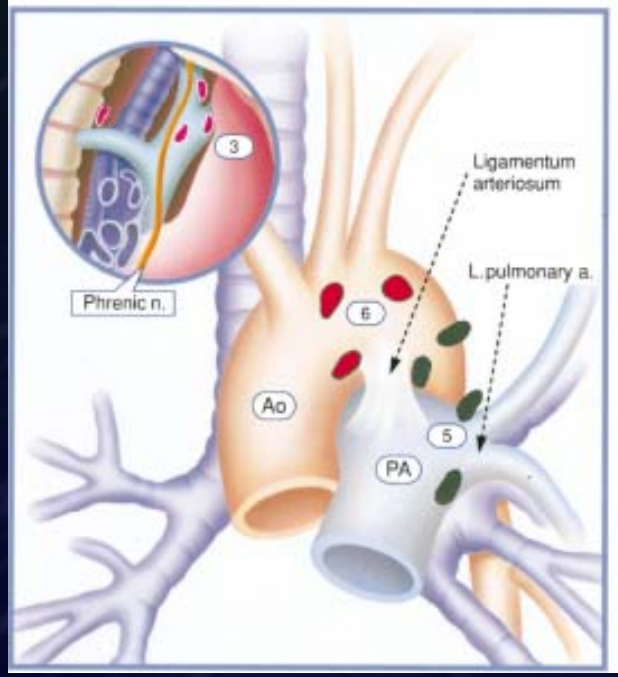



Pretracheal
A-P window

Subcarinal nodes collect lymph from the left lower lobe but drain that fluid into the right tracheobronchial lymph nodes. This is significant because **a suspicious-appearing lymph node in the right hilar region** should prompt evaluation of the left lower lobe and the right lung.







Superior Mediastinal Nodes

- **1** Highest Mediastinal
- **2** Upper Paratracheal
- **3** Pre-vascular and Retrotracheal
- **4** Lower Paratracheal (including Azygos Nodes)

N_2 = single digit, ipsilateral
N_3 = single digit, contralateral or supraclavicular

Aortic Nodes

- **5** Subaortic (A-P window)
- **6** Para-aortic (ascending aorta or phrenic)

Inferior Mediastinal Nodes

- **7** Subcarinal
- **8** Paraesophageal (below carina)
- **9** Pulmonary Ligament

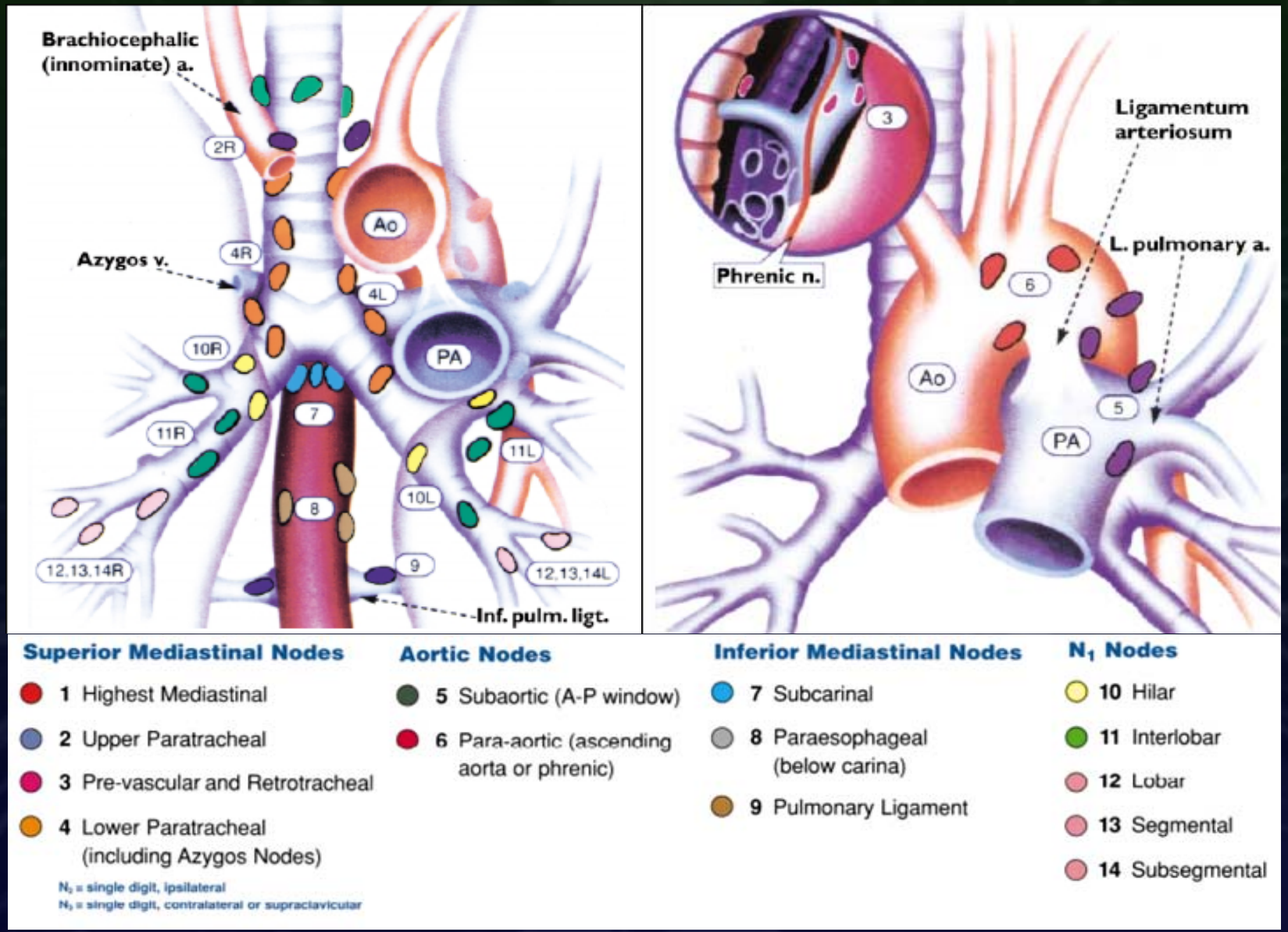
N_1 Nodes

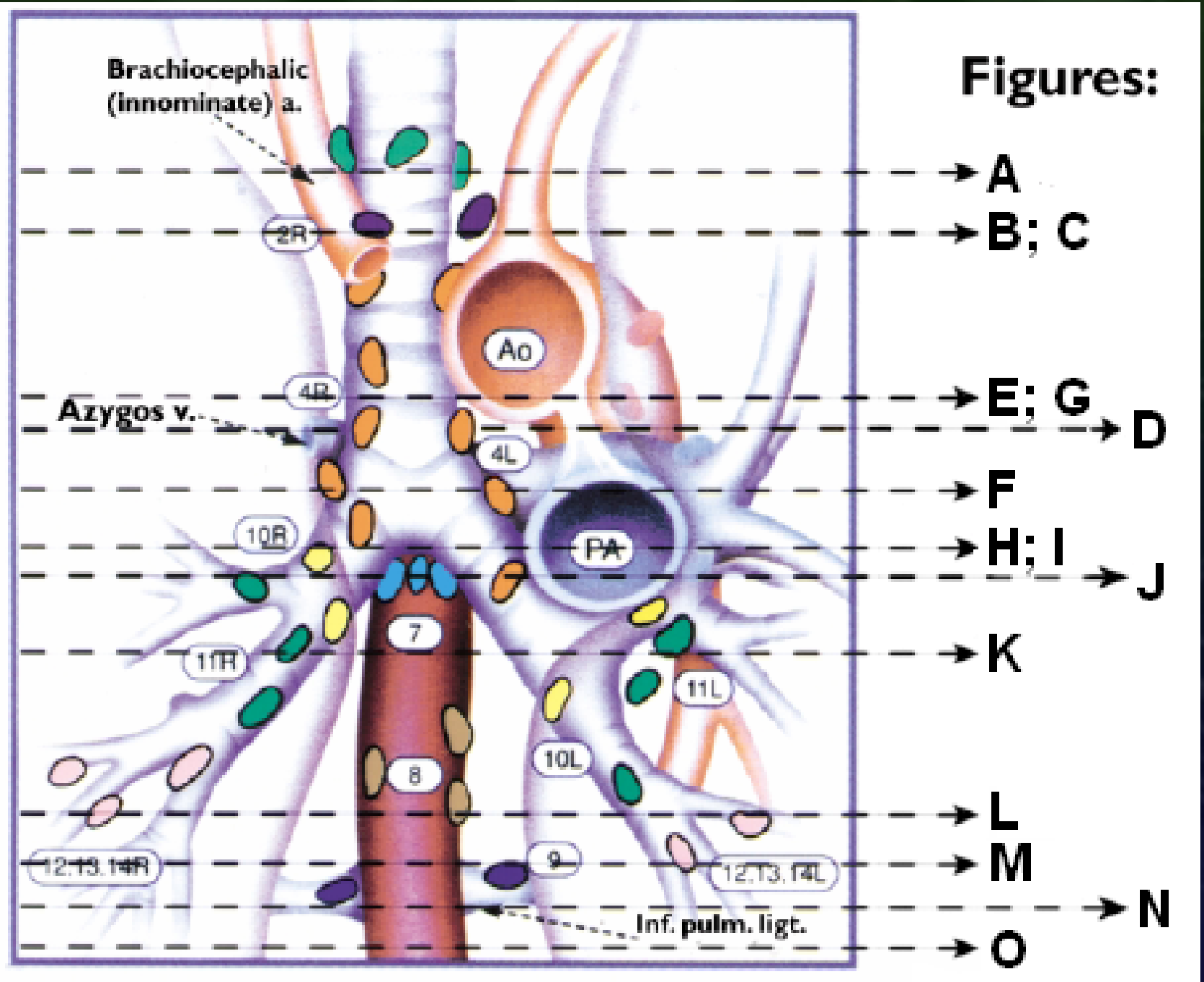
- **10** Hilar
- **11** Interlobar
- **12** Lobar
- **13** Segmental
- **14** Subsegmental

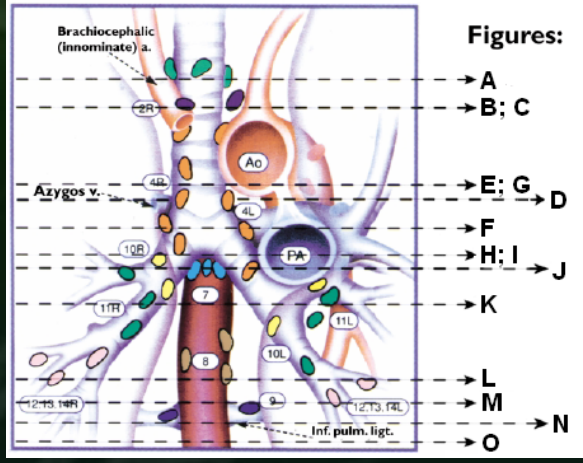
Personal discussion:
Tracheobronchial LN : paratrachial
Hilar LN : 2 cm away from tracheal (N1)
Bronchopulmonary LN : at 2nd order bifurcation of bronchus

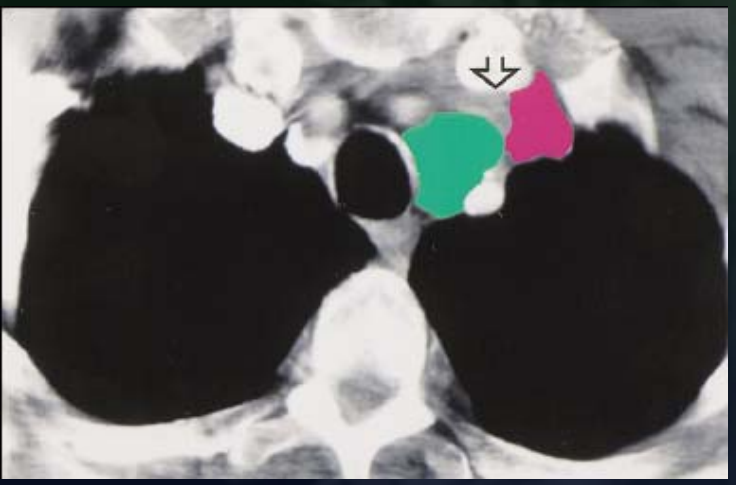
Regional LN classification for lung cancer staging
CF Mountain & CM Dresler
Chest 1997; 111; 1718-1723

Regional Lymph nodes: Lung CA



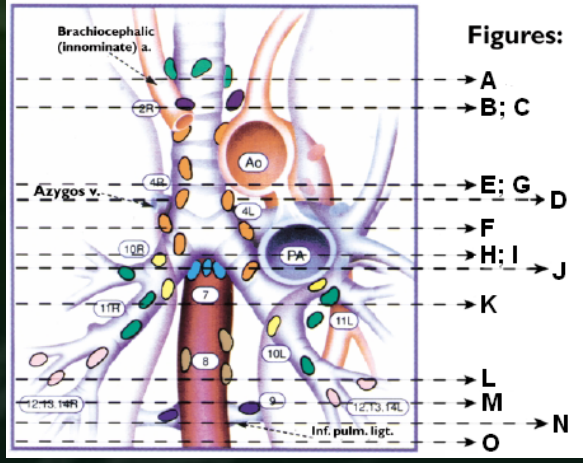

Brachiocephalic (innominate) a.
2R
Ao
4R
Azygos v.
4L
10R
PA
7
11R
11L
10L
8
12,13,14R
9
12,13,14L
Inf. pulm. ligt.
Figures:
A
B; C
E; G
D
F
H; I
J
K
L
M
N
O





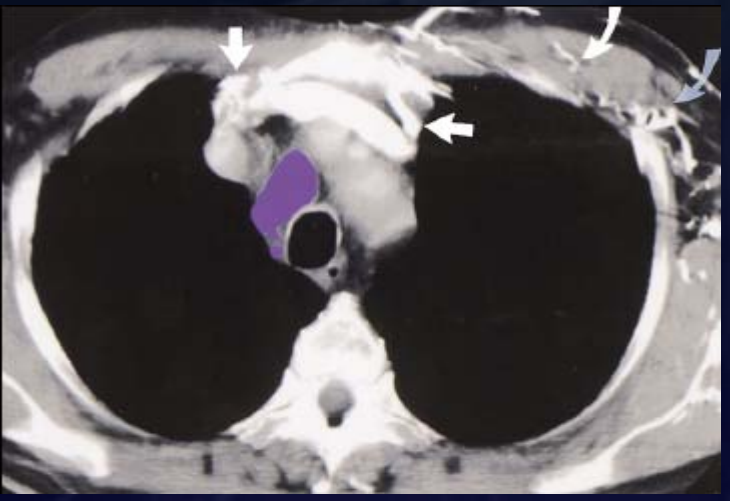
A

Station 1 **highest mediastinal node** (*light green*). Node is in left paratracheal region between left CCA and left SCA. This level is cranial to brachiocephalic vein where it crosses trachea. Note that station 3 prevascular node (*bright pink*) lies anterior to and left of major arterial vessels. More peripheral part of brachiocephalic vein is unopacified (*arrow*), medial to station 3 node.



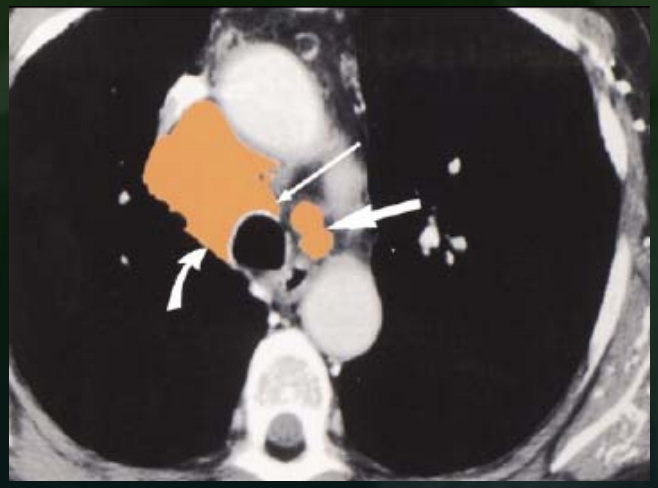
B

Station 2 **upper paratracheal node** (*dark purple*), which is extension of station 1 node in **A**. Brachiocephalic vein (*arrows*) crosses midline anterior to trachea and demarcates station 1 nodes from station 2 nodes. Station 3 prevascular node (*bright pink*) is again seen.



C

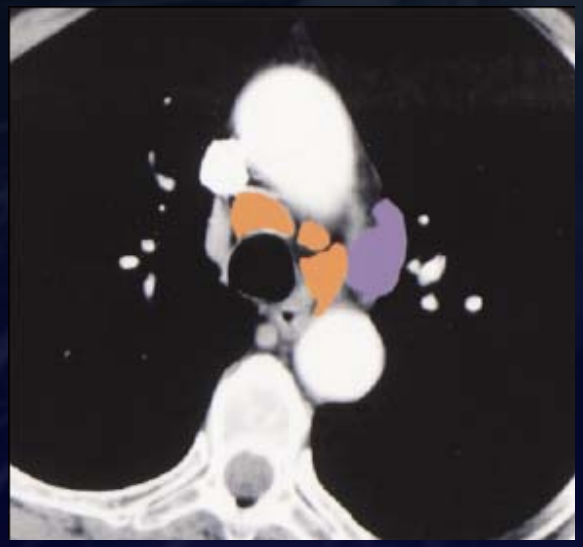
Station 2 **upper paratracheal node** (*dark purple*), which is below top of left brachiocephalic vein but above top of aortic arch. IV contrast injection was made through left brachiocephalic vein. Note reflux into anterior chest wall collaterals (*curved arrows*) and both internal mammary veins (*straight arrows*).



E

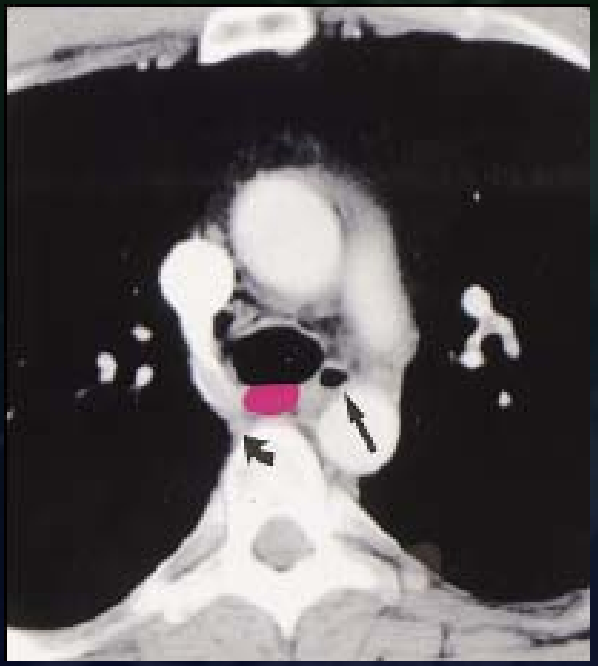
Station 4 **lower paratracheal nodes** (*bright orange*) can be separated into superior and inferior subsets. Nodes shown are in superior subset, meaning they are inferior to top of aortic arch and above azygos vein. Along with other mediastinal nodes, these station 4 superior lower paratracheal nodes can be separated into those to right (4R) (*curved arrow*) or left (4L) (*straight thick arrow*) of midline.

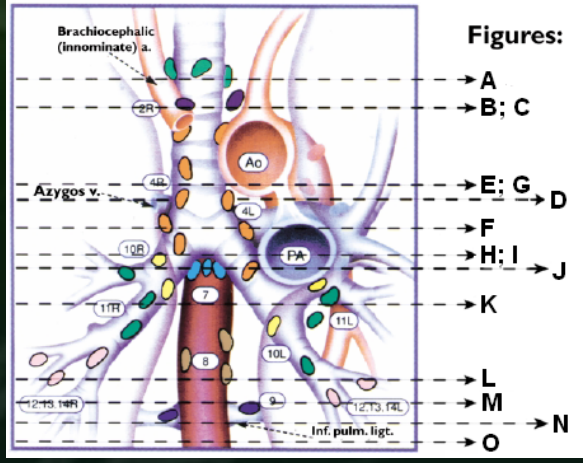
Midline nodes (*thin arrow*) are considered to be on same side as primary lung tumor. Therefore, in this patient with right lower lobe mass, midline nodes anterior to trachea are categorized as station 4 superior lower paratracheal nodes.



G

Station 5 **AP window nodes** (*light purple*) are lateral to, and station 4 superior lower paratracheal nodes (*bright orange*) are medial to, ligamentum arteriosum.

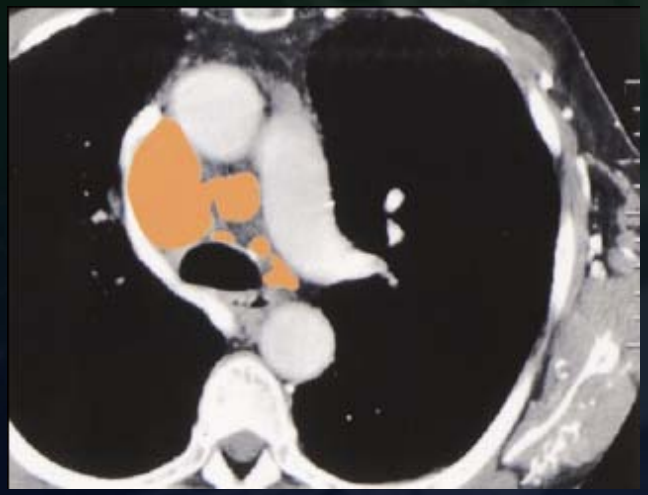


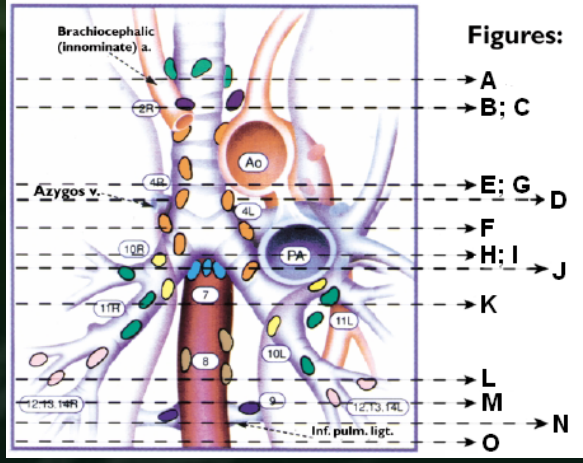


D

Station 3 **retrotracheal node** (*bright pink*), which is posterior to trachea at midline between esophagus (*straight arrow*) and azygos vein and arch (*curved arrow*).

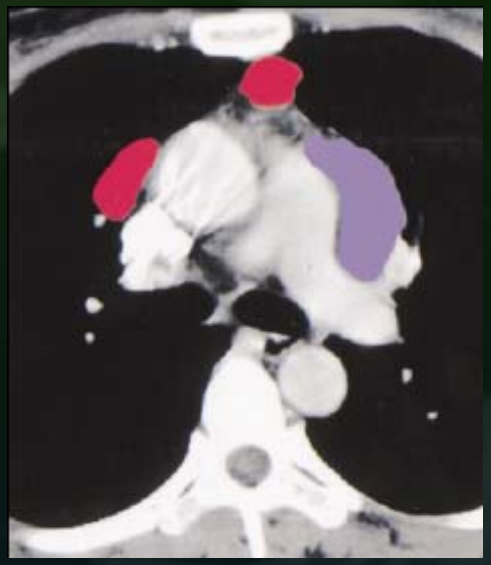
Azygos vein is opacified by retrograde contrast material from superior vena cava.





F

Station 4 **inferior lower paratracheal nodes** (*bright orange*), which are below horizontal line drawn at superior aspect of azygos vein. Nodes are contiguous with station 4 superior lower paratracheal nodes in **E**.

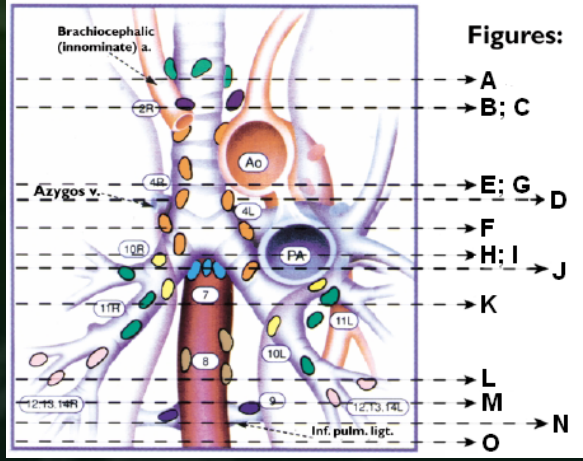


H

Station 6 **paraaortic** (ascending aortic or phrenic) nodes (*red*) anterior to superior vena cava on right and anterior to aorta and main pulmonary artery to left of midline. Station 5 AP window nodes (*light purple*).

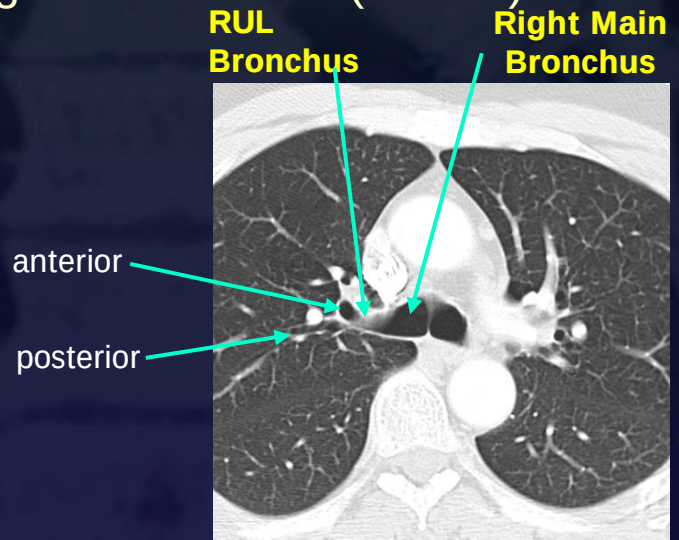
I

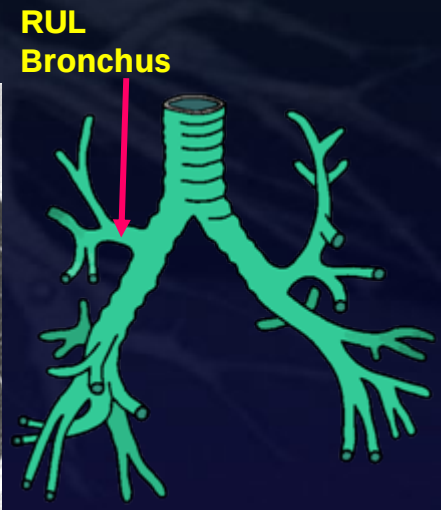
Station 7 **subcarinal nodes** (*teal blue*) extending anterior and posterior to main bronchi. Anterior aspect of subcarinal nodes can be reached by cervical mediastinoscopy via approach anterior to trachea and carina. Station 8 **paraesophageal node** (*tan*) lies posterolateral to esophagus (*white arrow*) between azygos vein (*black arrow*) and aorta. Station 4 lower paratracheal nodes are bright orange, station 13 segmental nodes are light pink, station 10 hilar nodes are yellow, and station 4 inferior lower paratracheal nodes are bright orange.

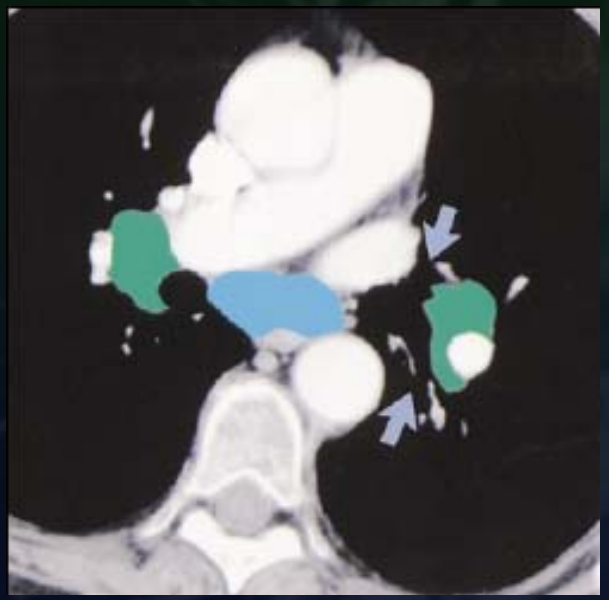


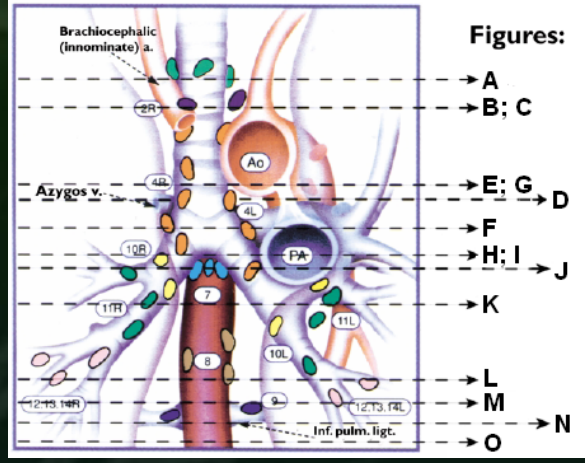
J

Station 10 **hilar nodes** (*yellow*), which are anterior and posterior to right upper lobe bronchus. They are inferior to top of right upper lobe bronchus, a demarcation point between station 4 mediastinal and station 10 hilar nodes. Note station 7 subcarinal node (*teal blue*). Station 13 segmental node (*light pink*) lies between right upper lobe anterior and posterior segmental bronchi (*arrows*).









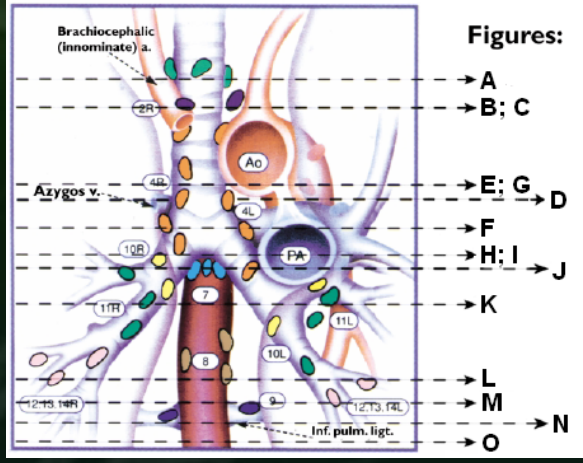
K

Station 11 **interlobar nodes** (*dark green*) at level of main pulmonary artery and proximal bronchus intermedius.

On left, they lie between lingular and left lower lobe superior segmental bronchi (*arrows*).

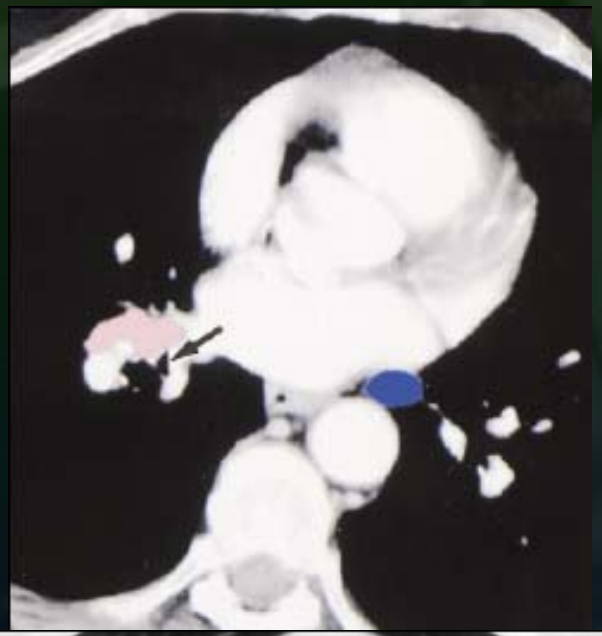
On right, they are lateral to bronchus intermedius and inferior to right upper lobe bronchus.

Subcarinal station 7 nodes (*teal blue*) are present.



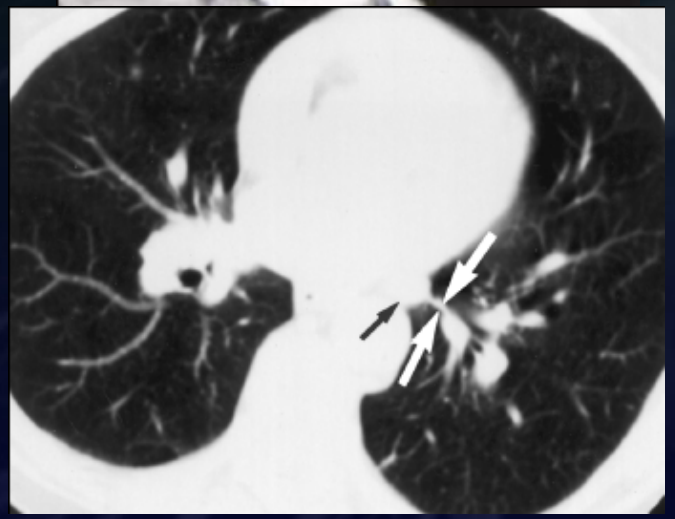
L

Station 8 **paraesophageal node** (*tan*) is anterior to azygos vein (*curved arrow*) and lateral to esophagus (*straight arrow*).

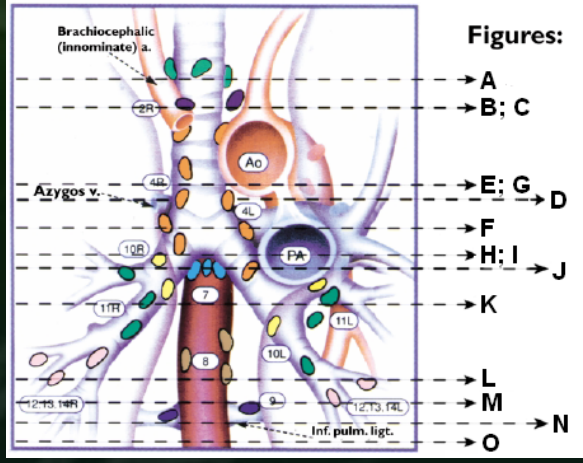


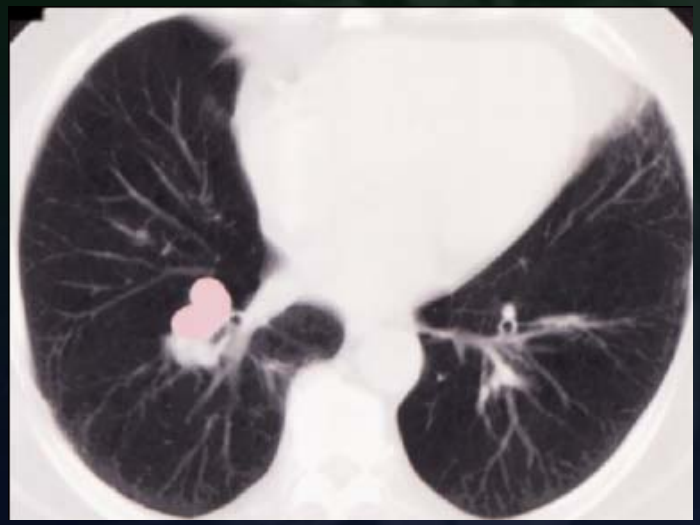
M

Station 12 **lobar nodes** (*light pink*) that are adjacent to distal lobar bronchi. Level is just inferior to right middle lobe bronchus near branching of medial basal bronchus (*arrow*) that is bifurcating from truncus basalis. Station 9 **inferior pulmonary ligament node** (*dark blue*) lies medially within inferior pulmonary ligament.



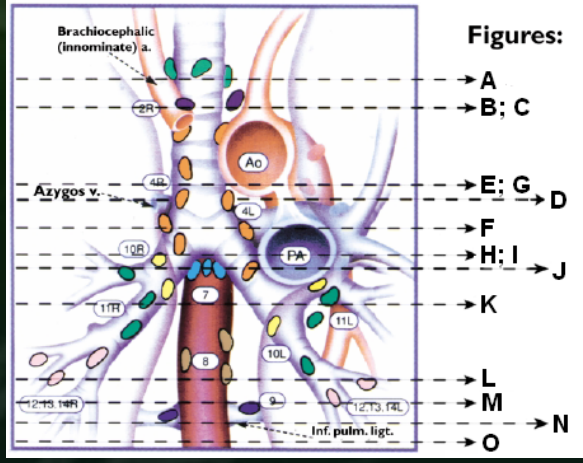
Same section viewed with lung window settings shows inferior pulmonary ligament (*white arrows*) adjacent to node (*black arrow*). Pulmonary ligaments course caudally from inferior hilum to diaphragm. Nodes in inferior pulmonary ligaments are contained in four pleural reflections and therefore are in mediastinum.





N

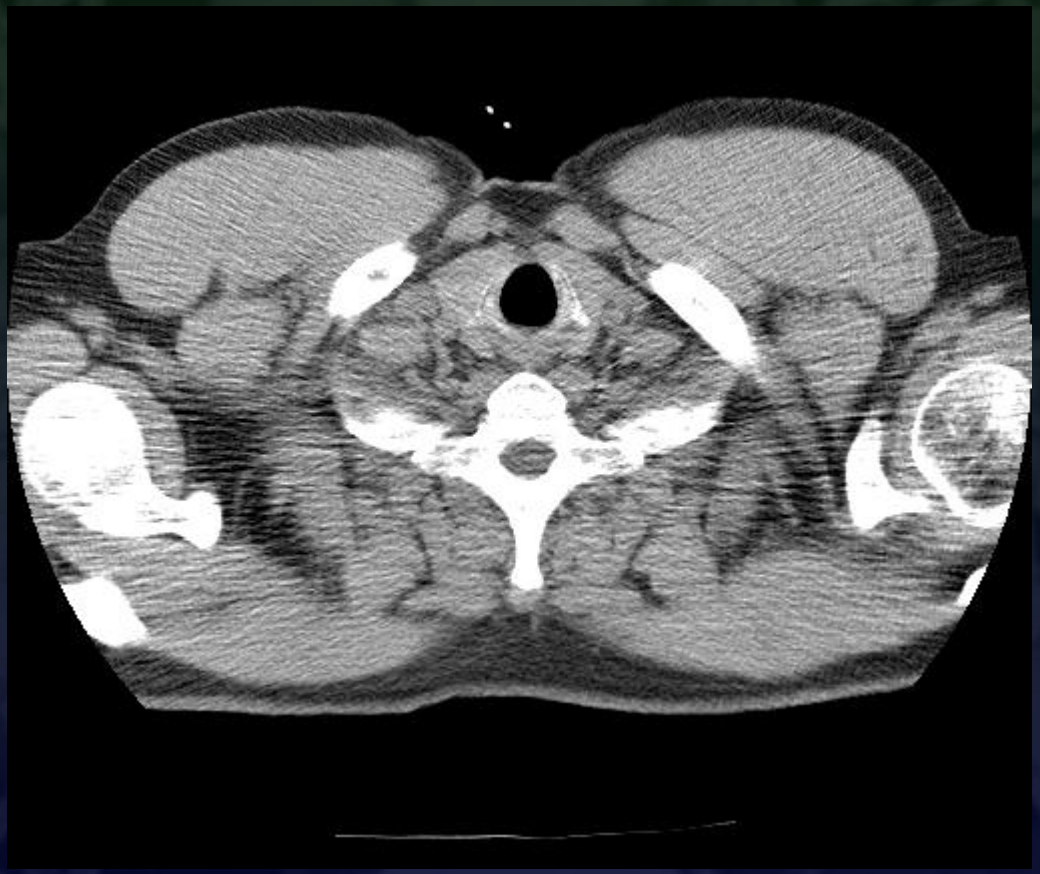
Station 13 **segmental nodes** (*light pink*) are anterior to lateral basal bronchus.

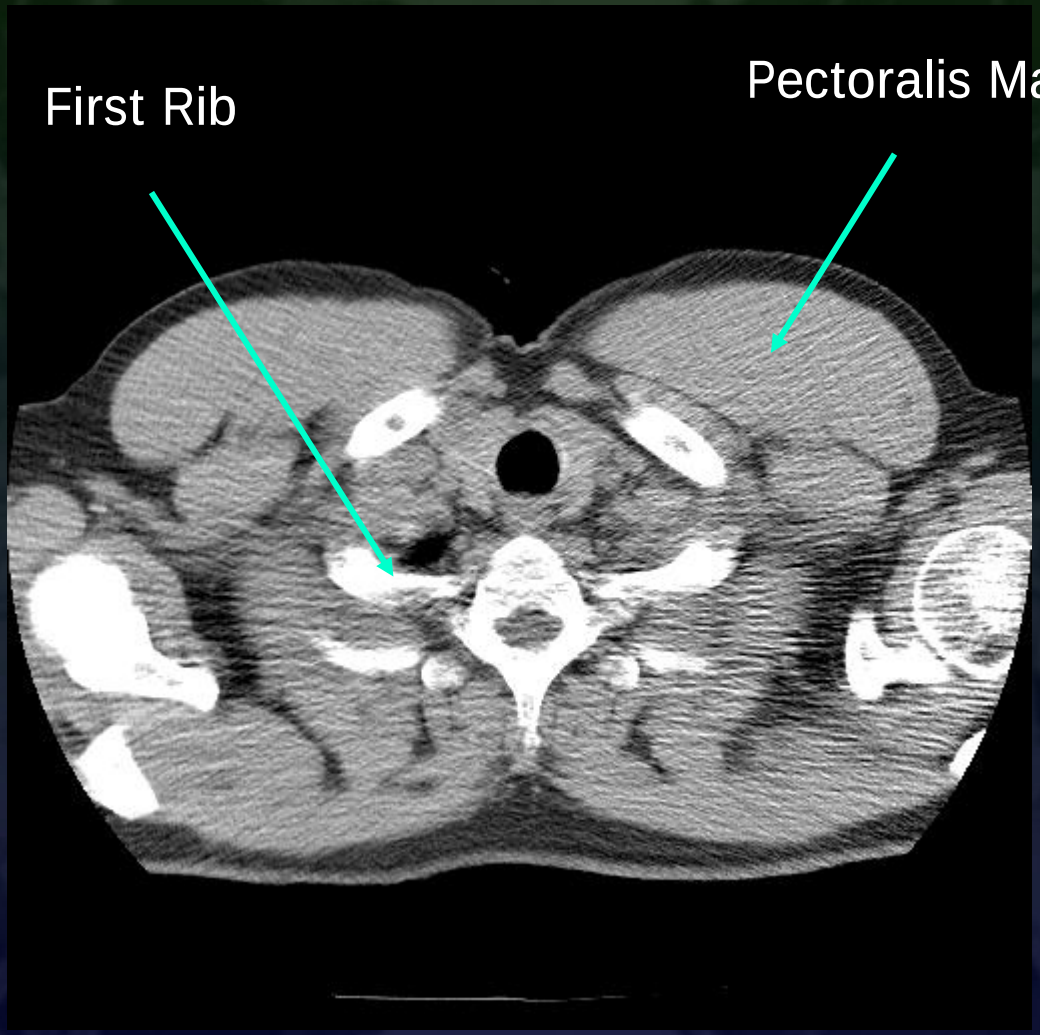


O

Station 14 **subsegmental node** (*light pink*) adjacent to subsegmental bronchus (*curved arrow*). Ground-glass opacity (*straight arrow*) in right lower lobe periphery represents top of primary tumor.

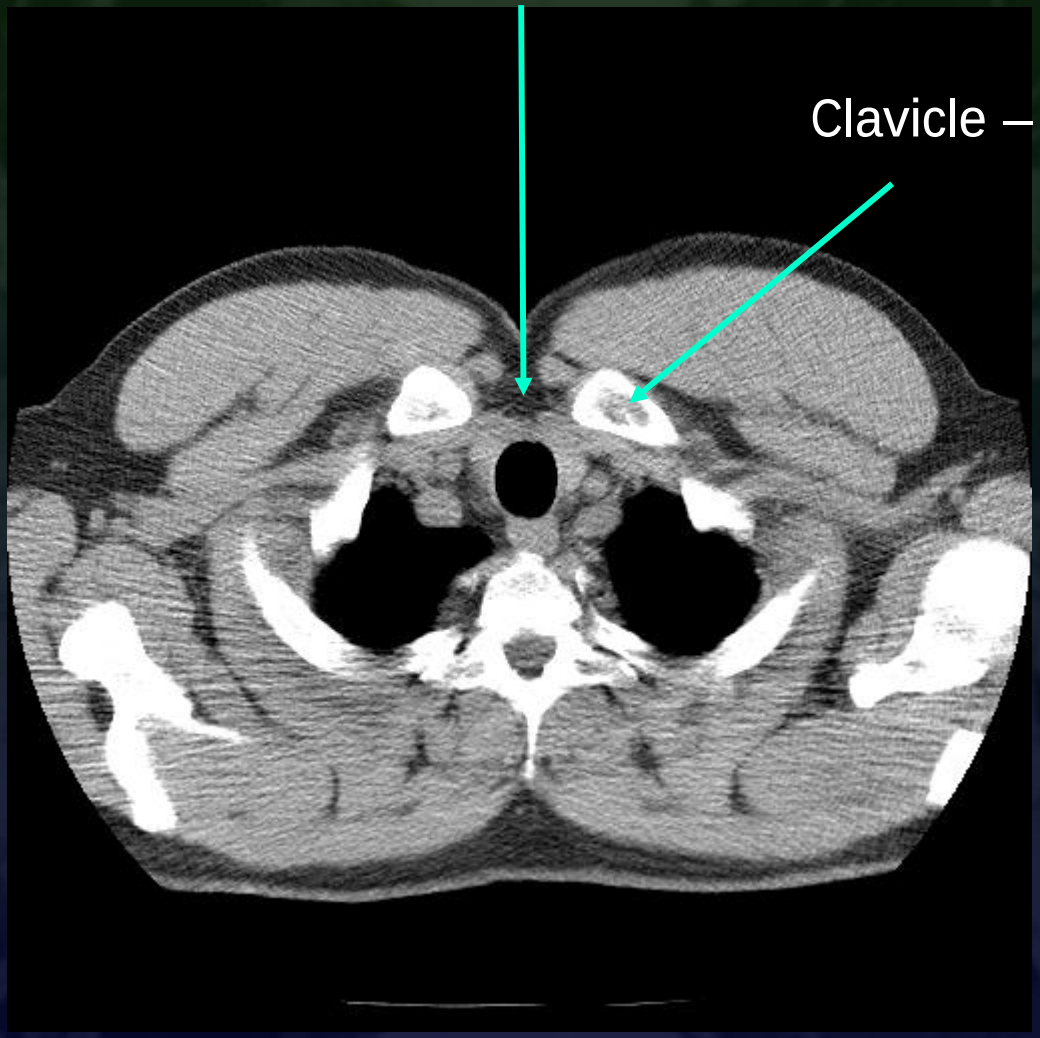
Non-contrast Chest
Bony and Muscular Landmarks



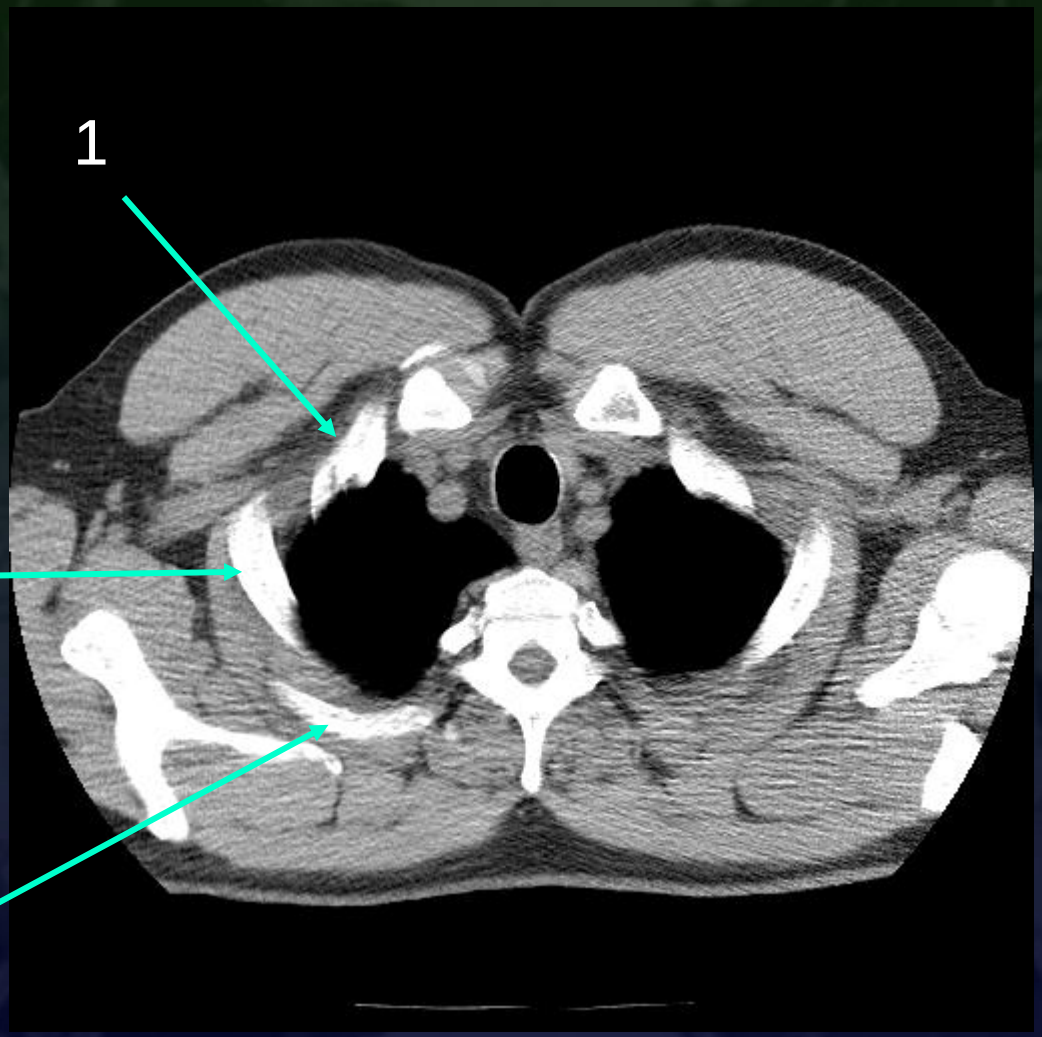

First Rib
Pectoralis Major

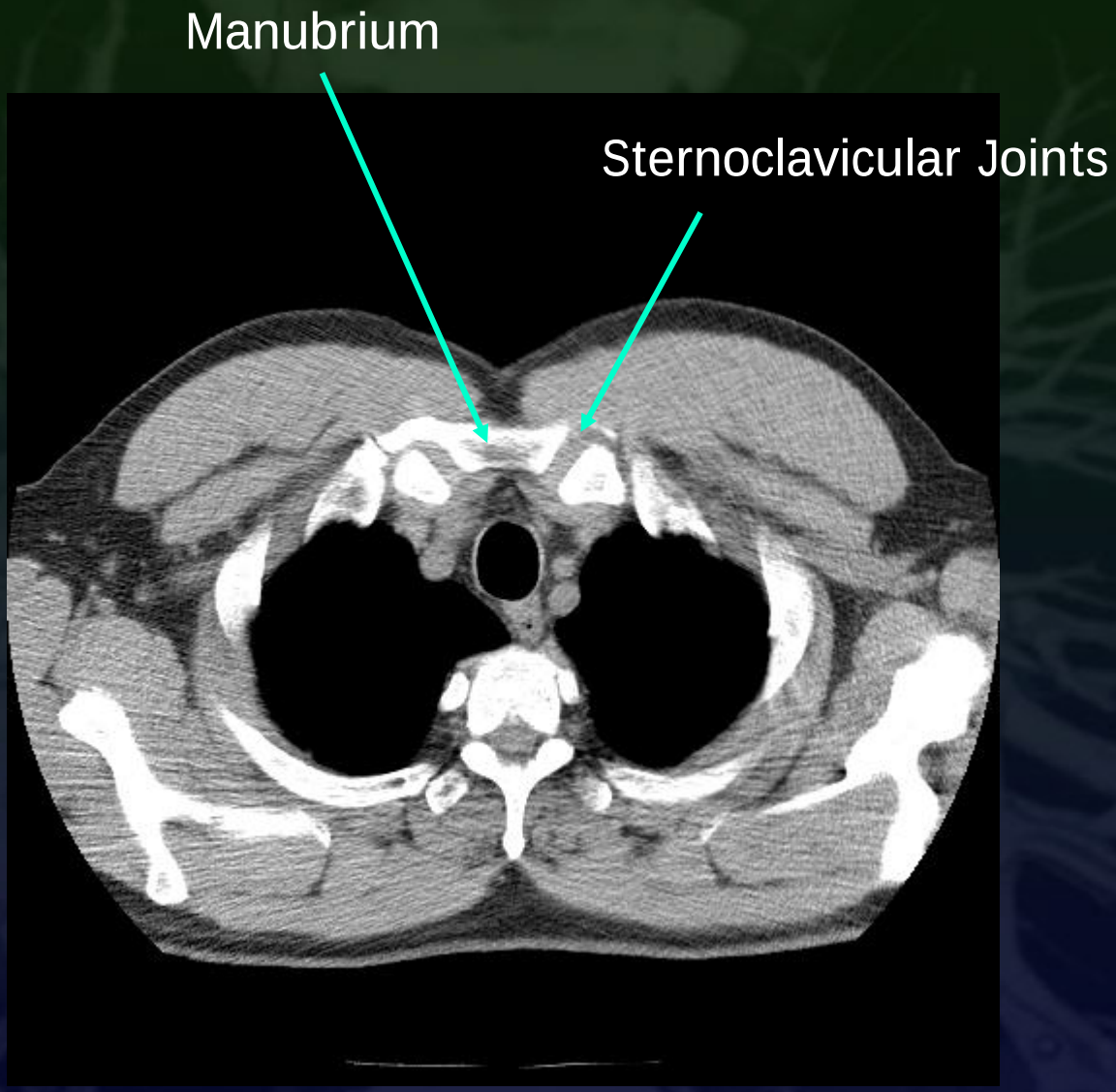
Sternal Notch

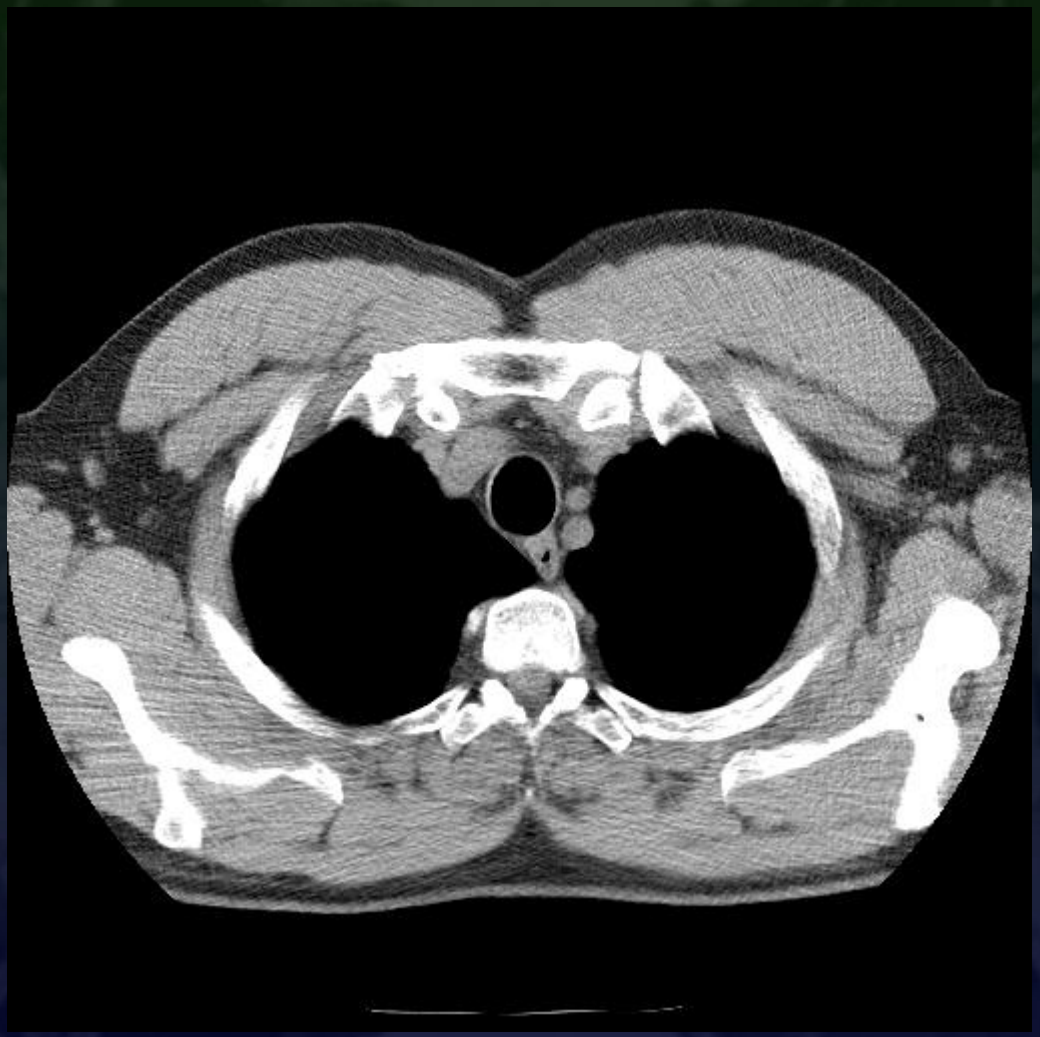
Clavicle – Medial End

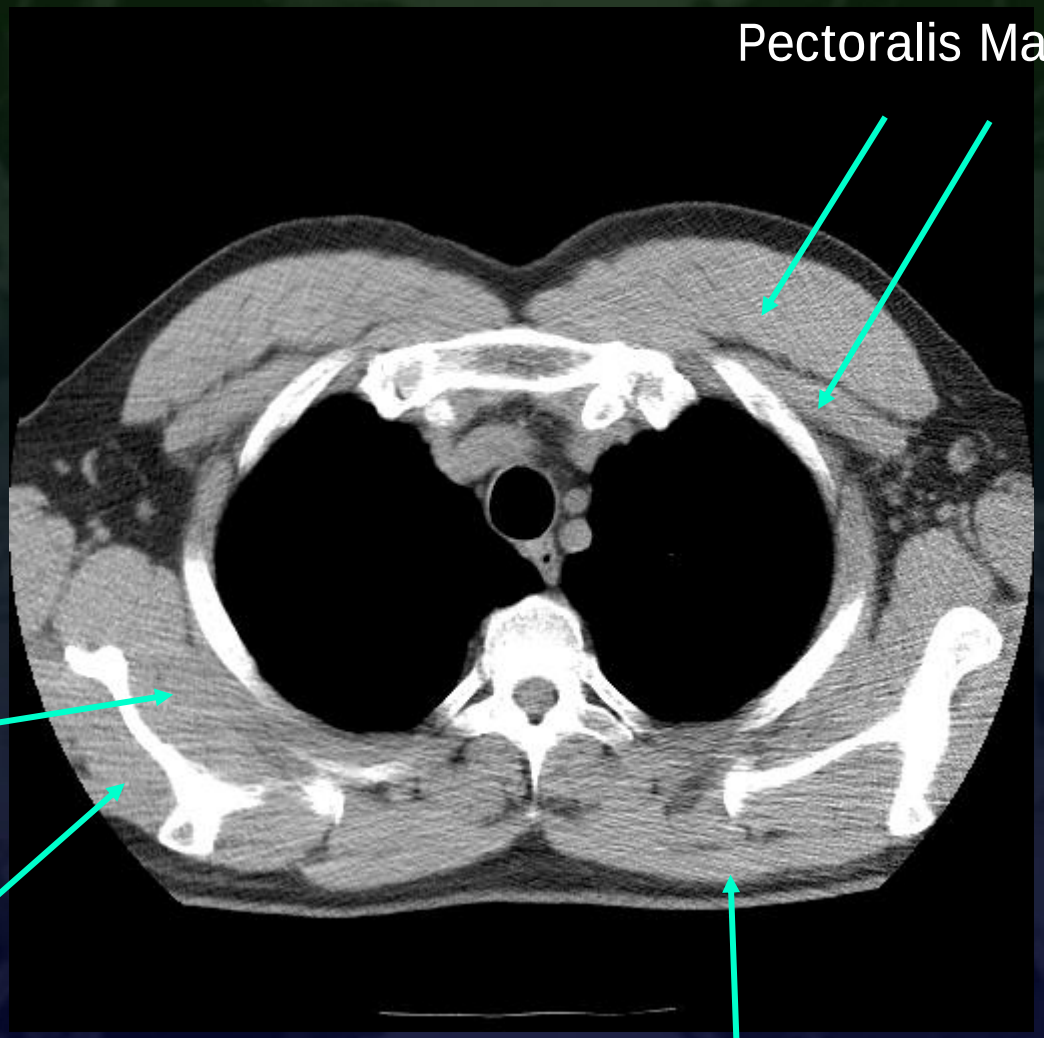


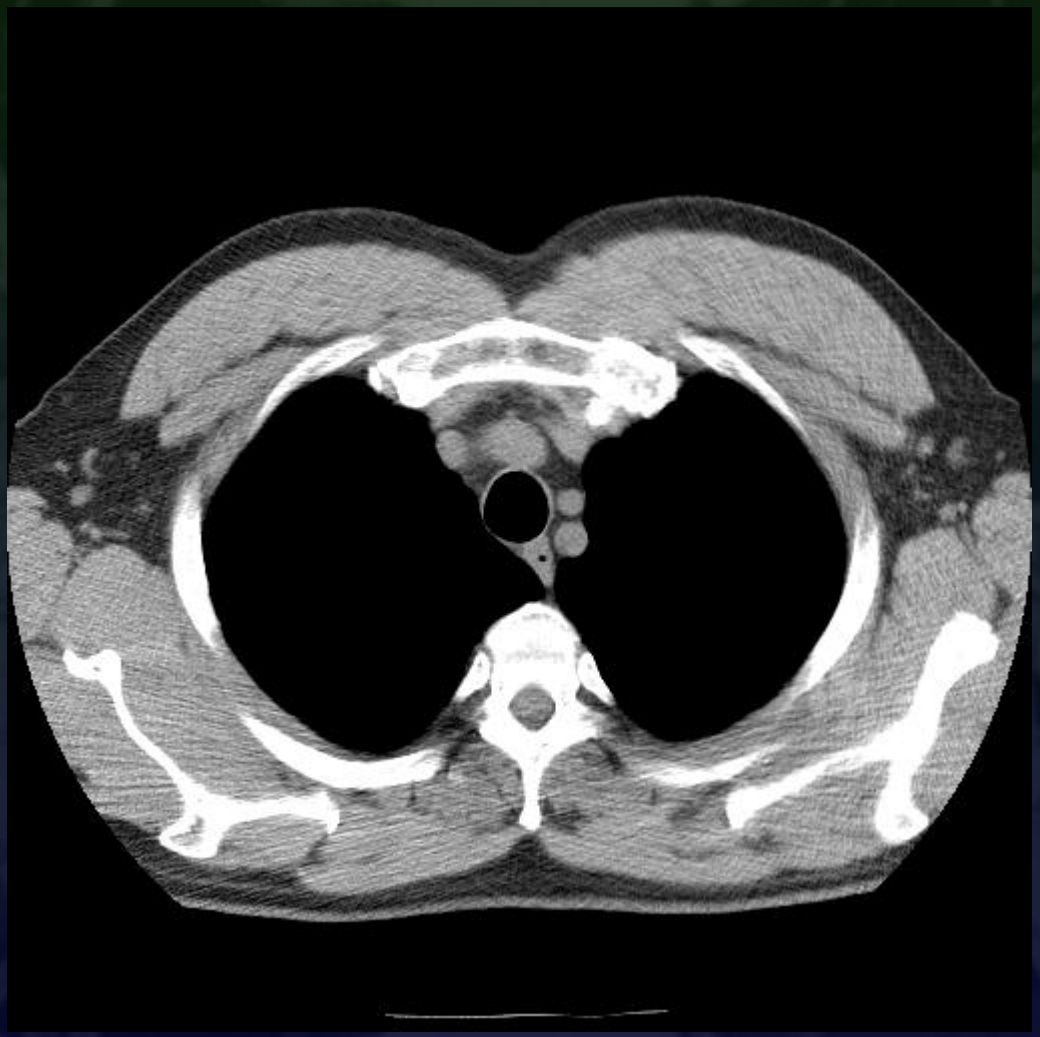
Counting the ribs!

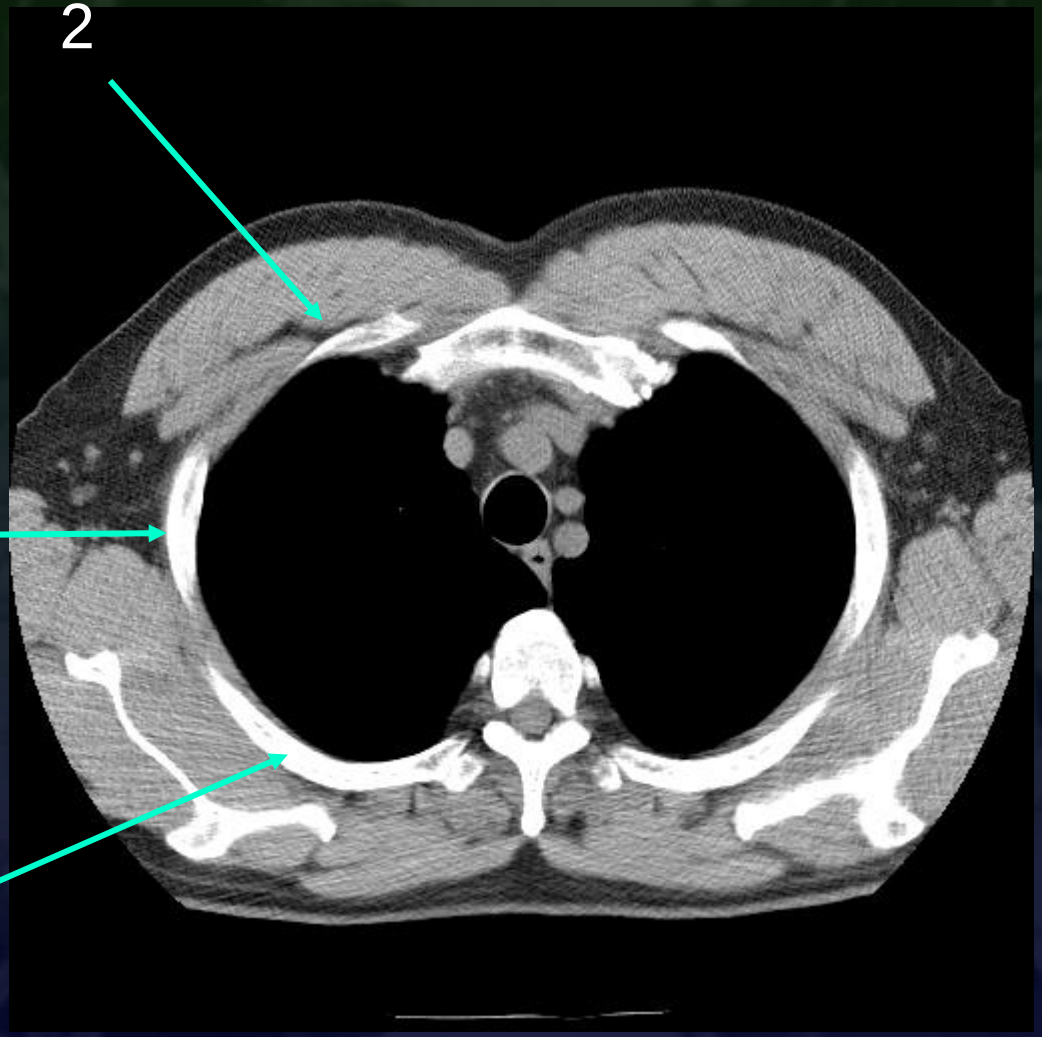


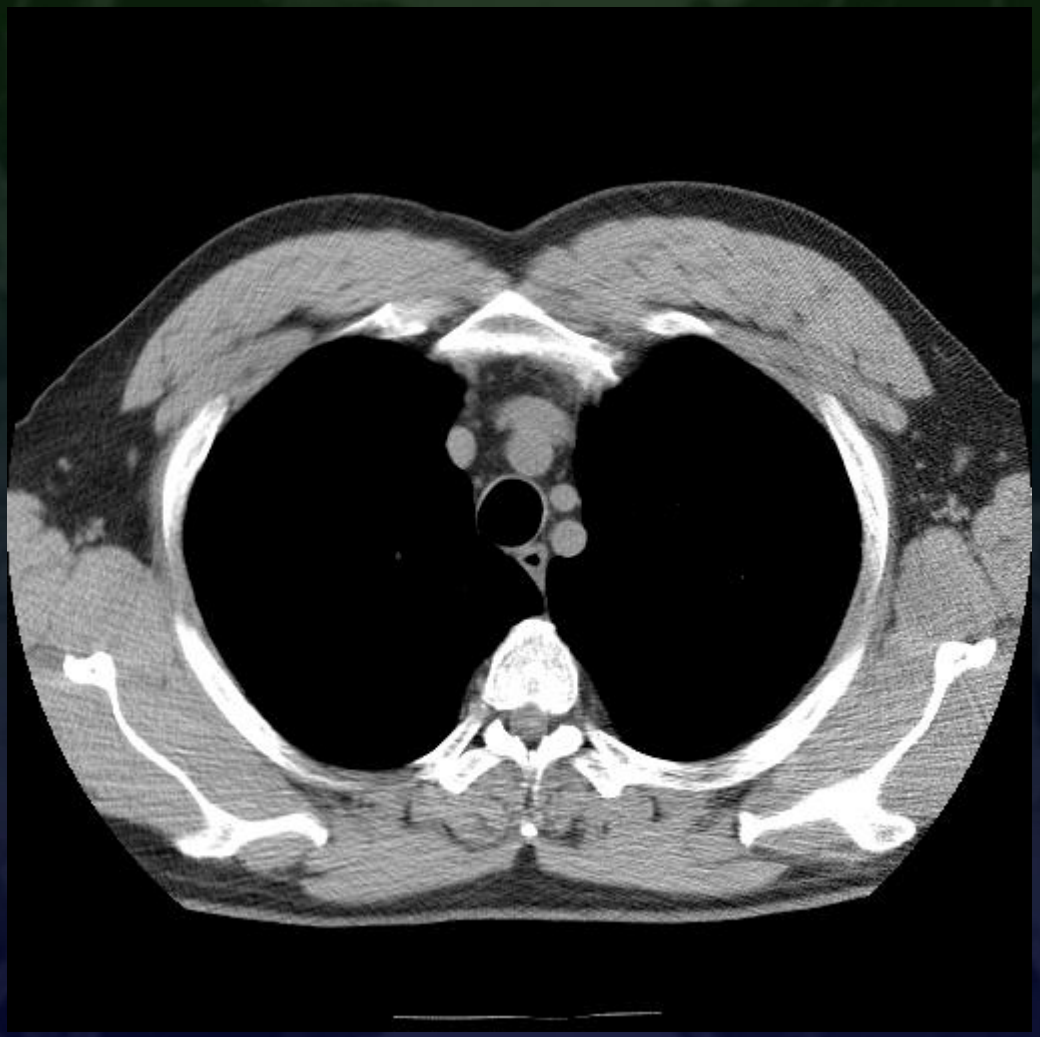

Manubrium
Sternoclavicular Joints

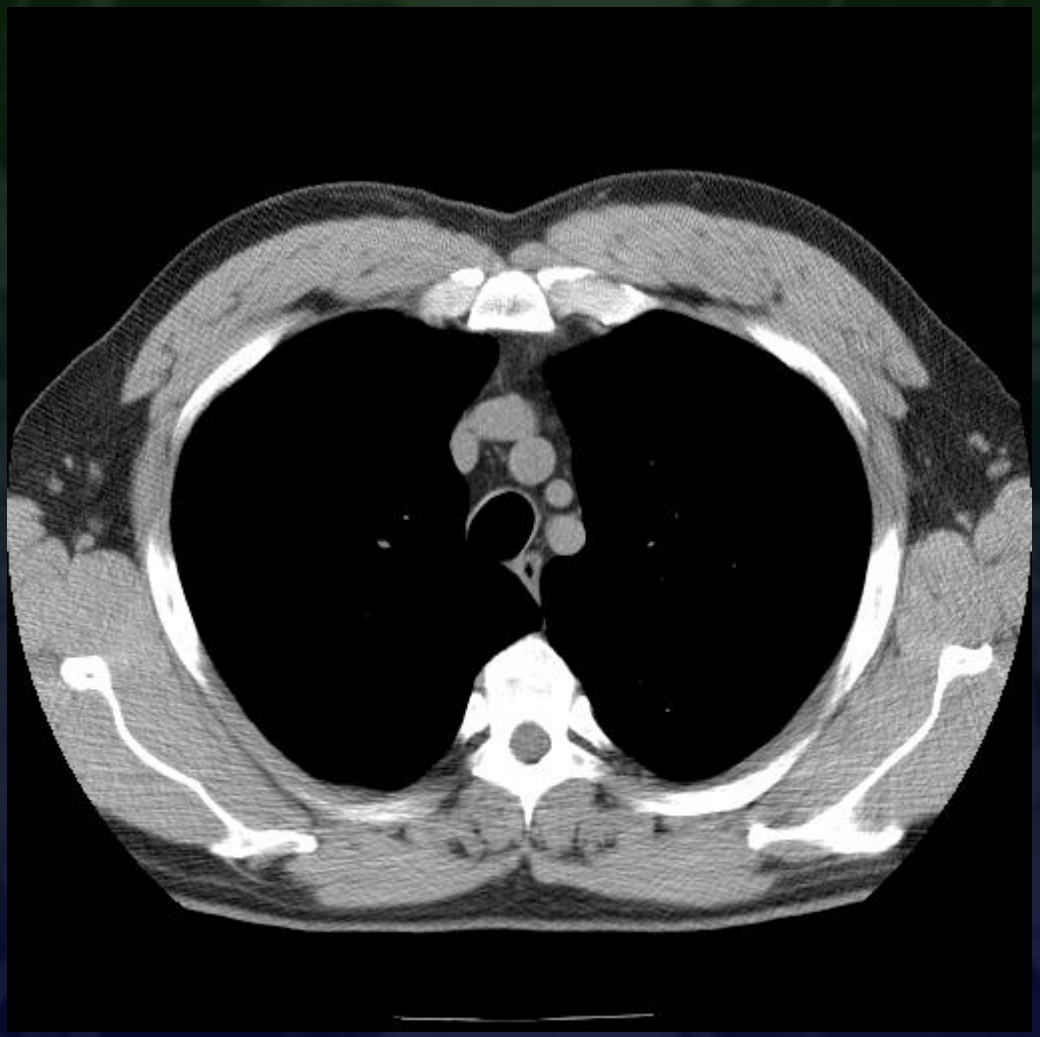


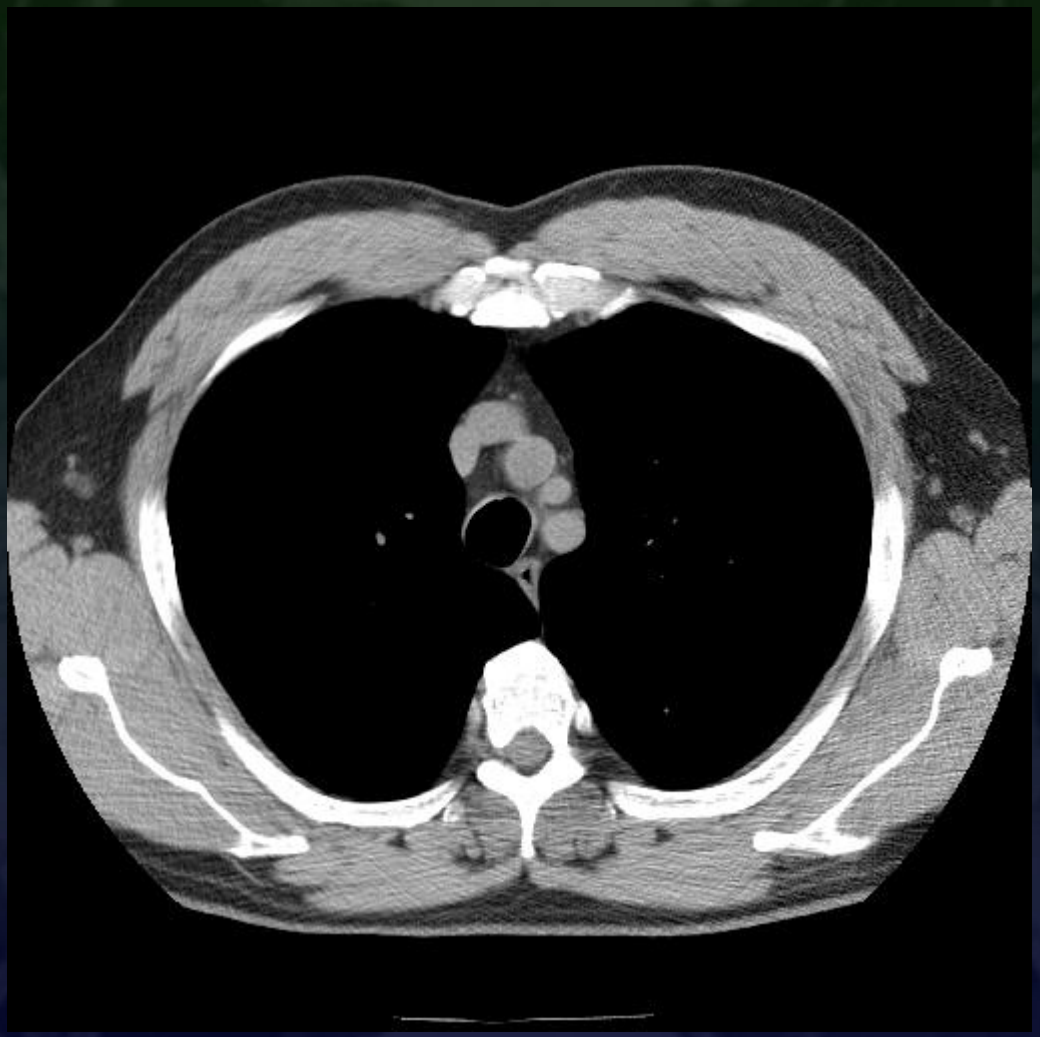

Pectoralis Major and Minor
Subscapularis
Supraspinatus
Trapezius

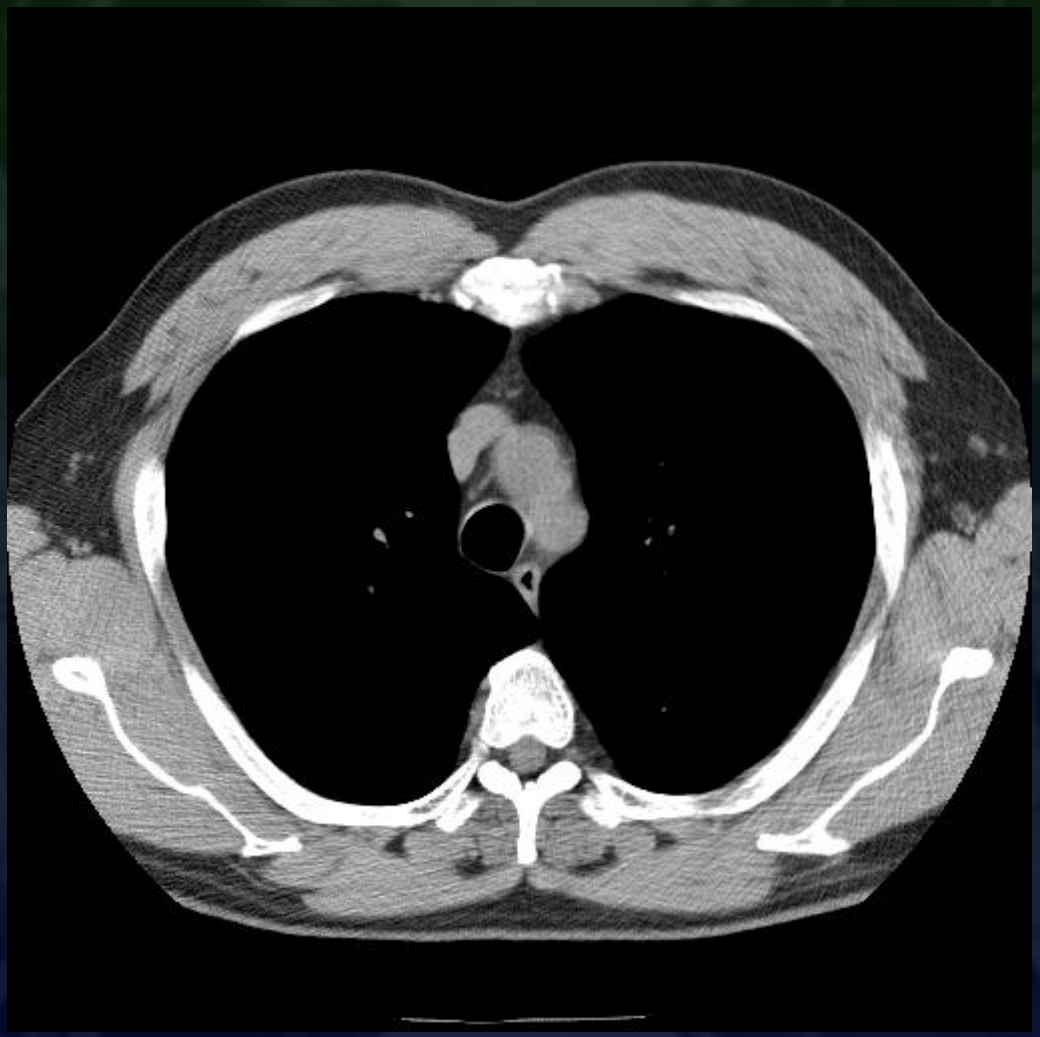


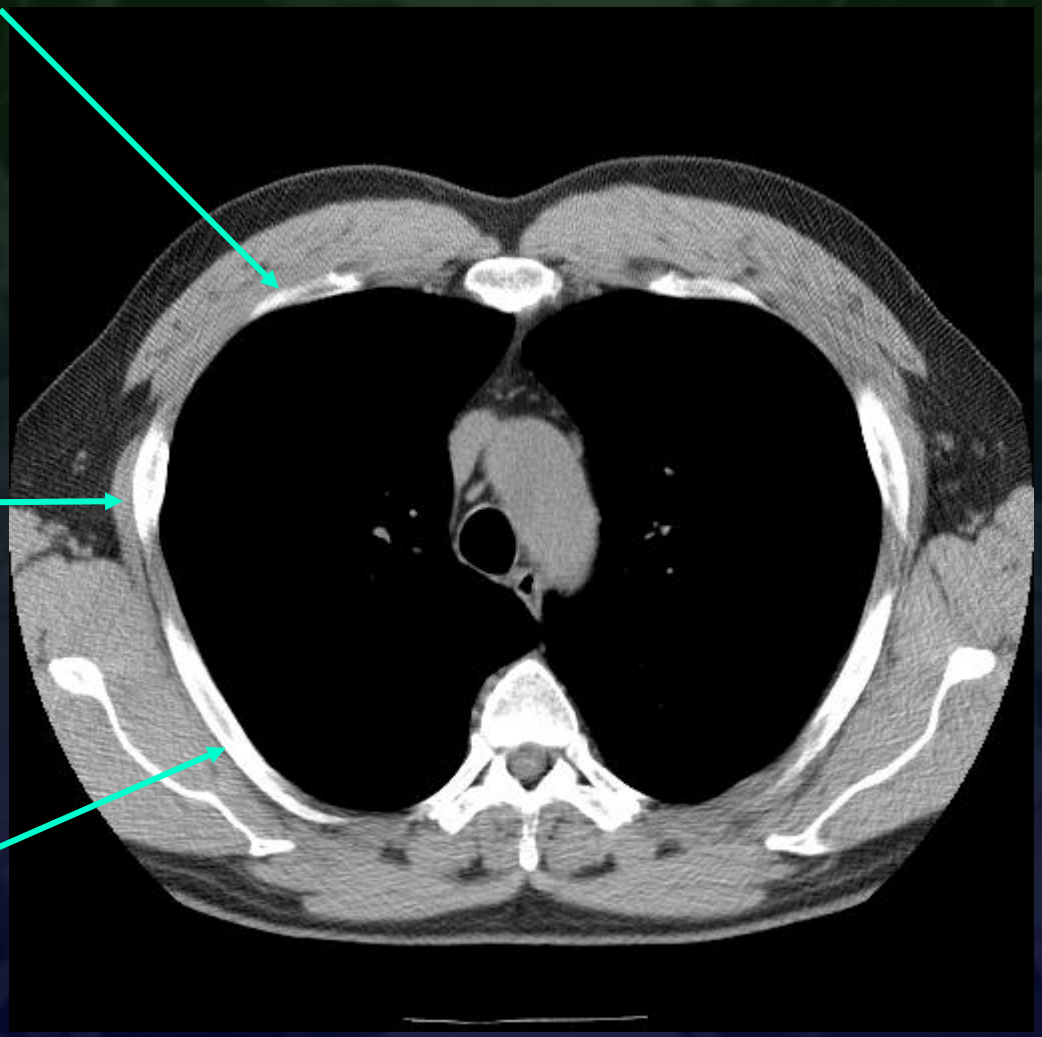

2
3
4







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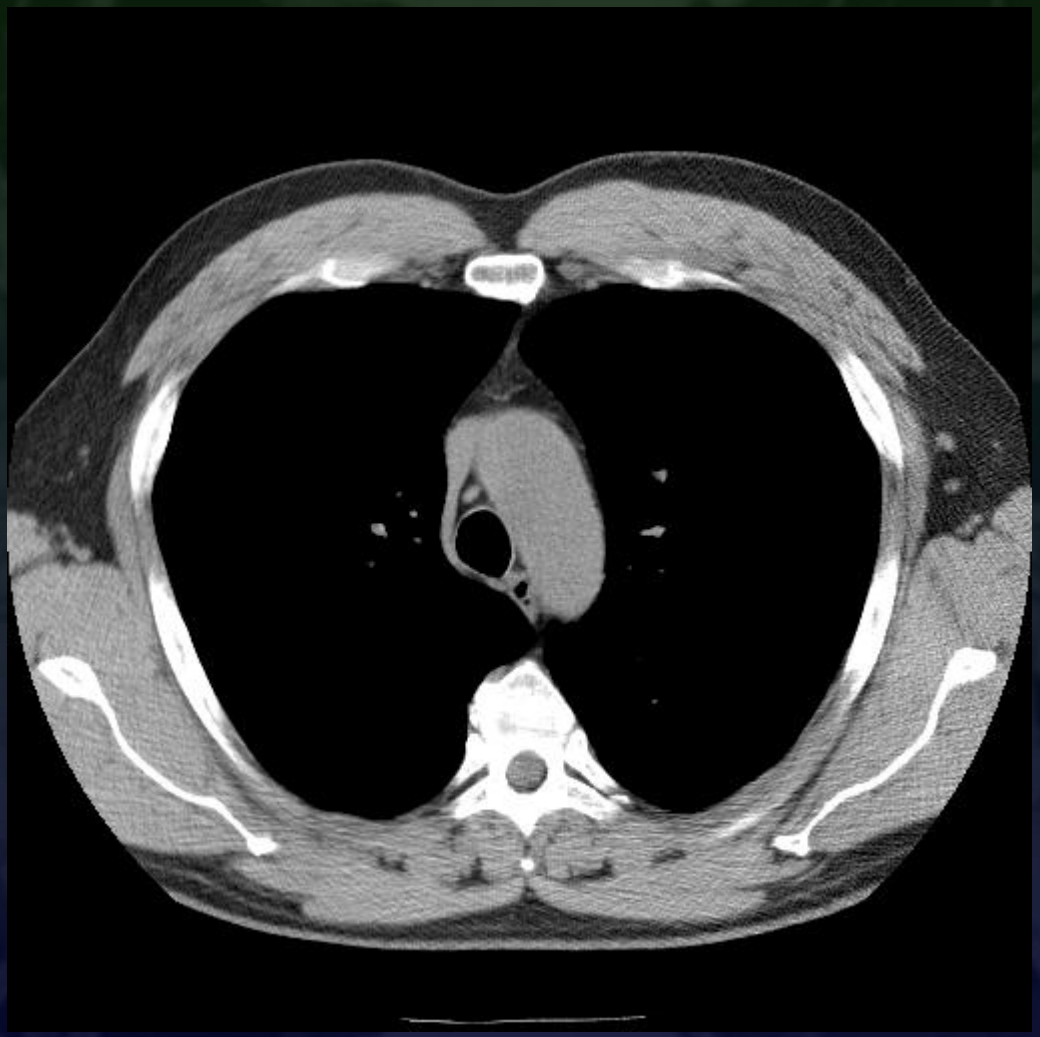

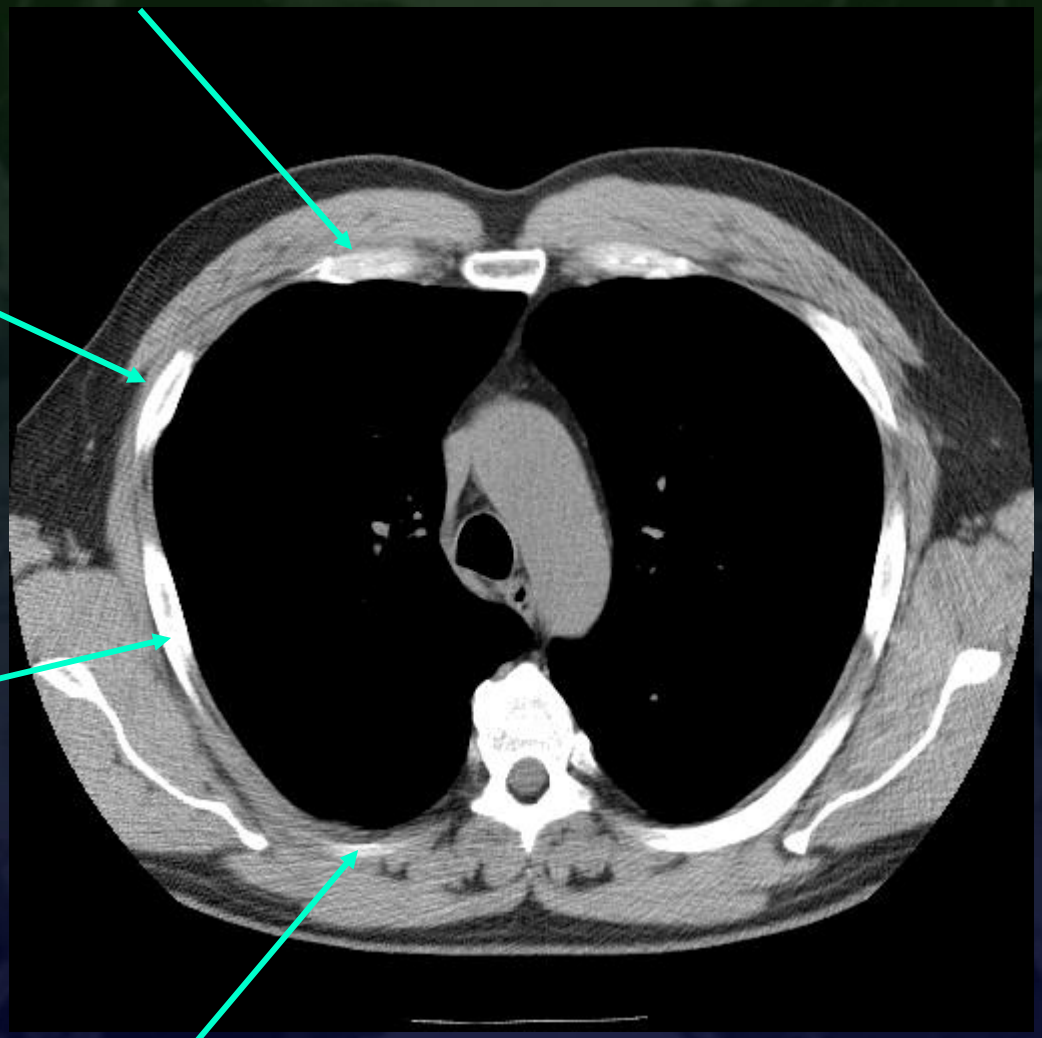
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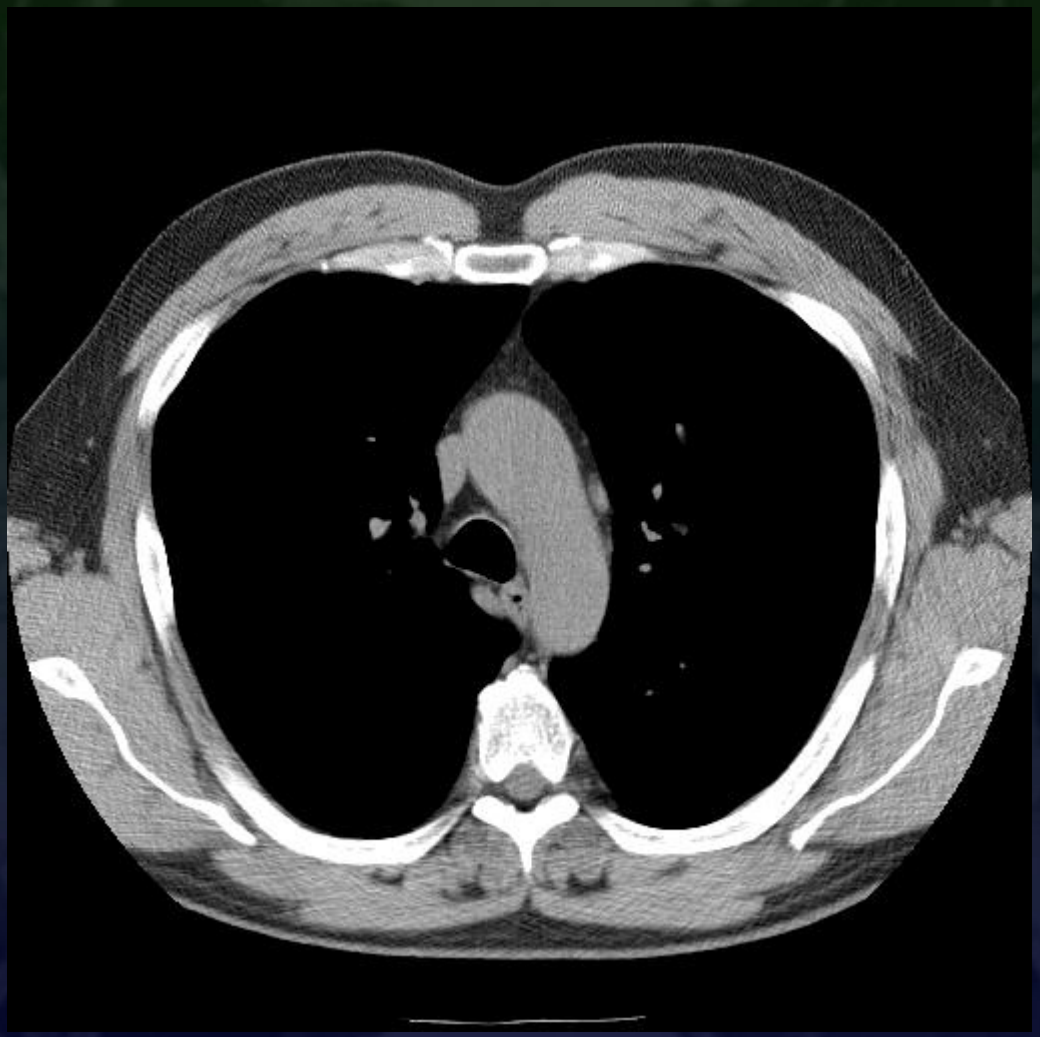
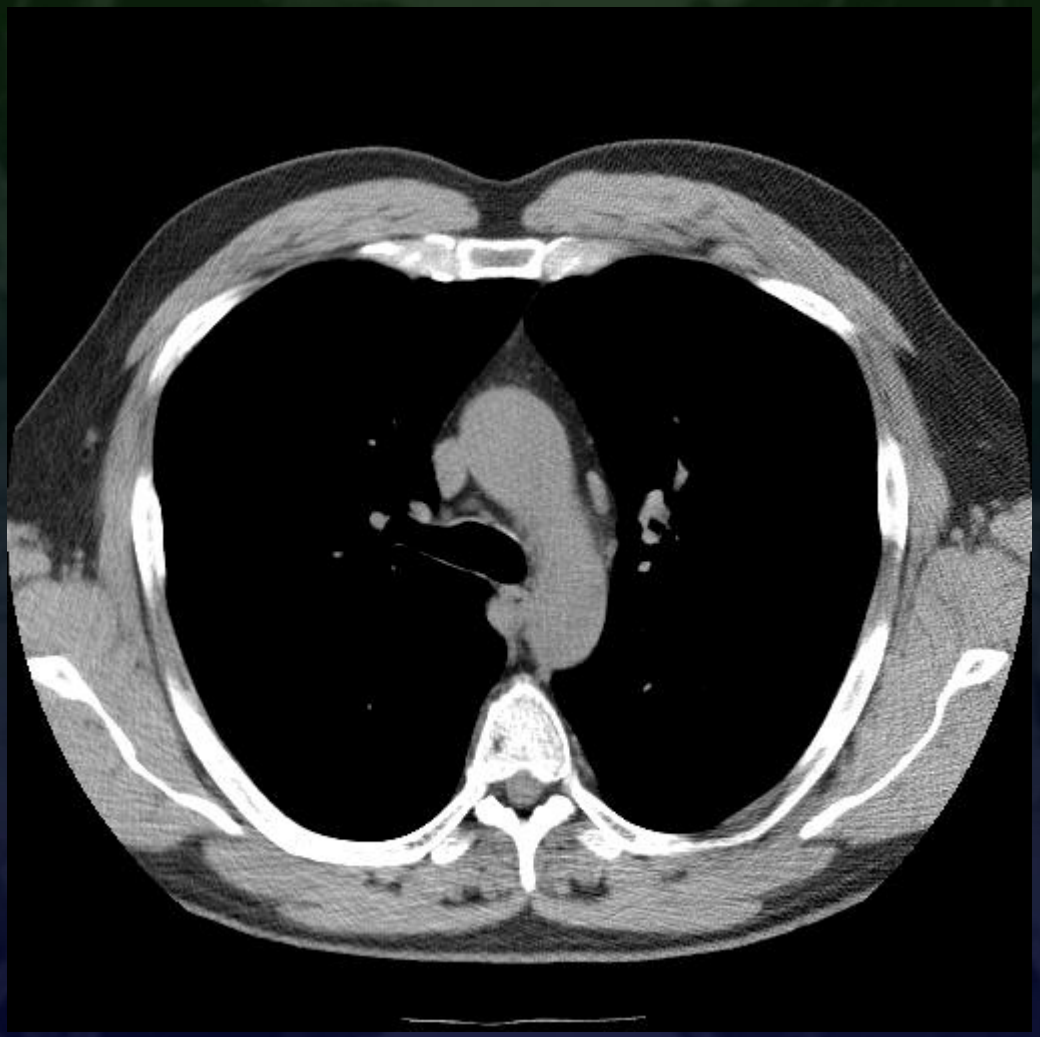
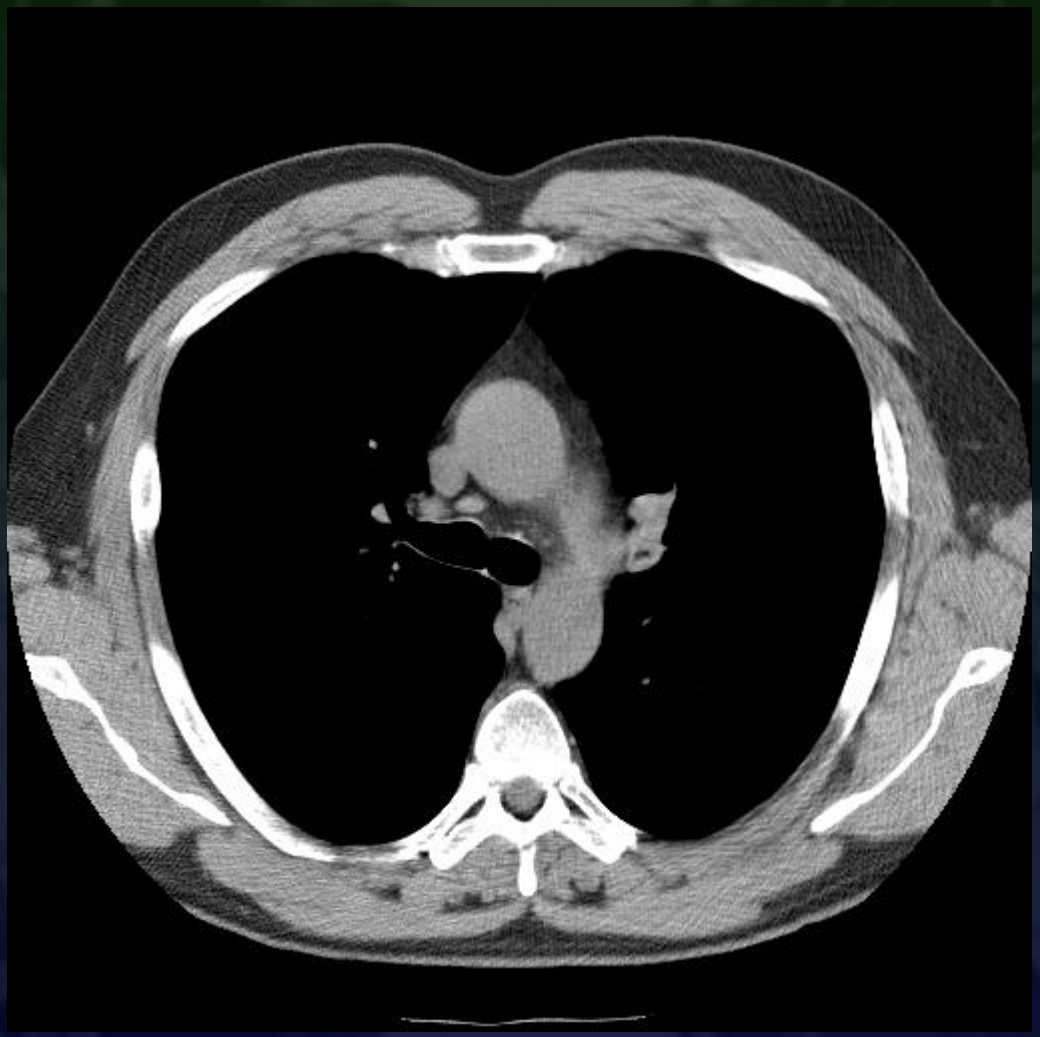
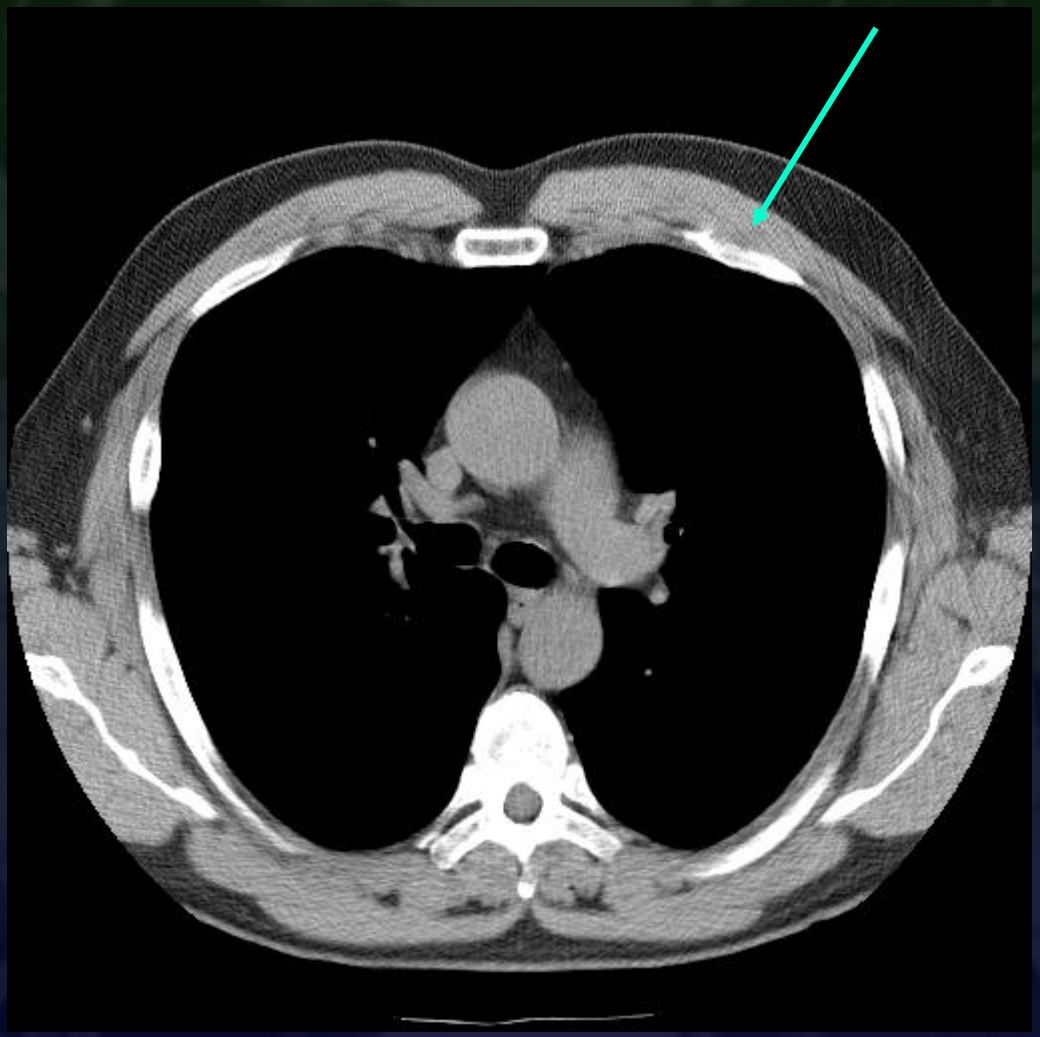
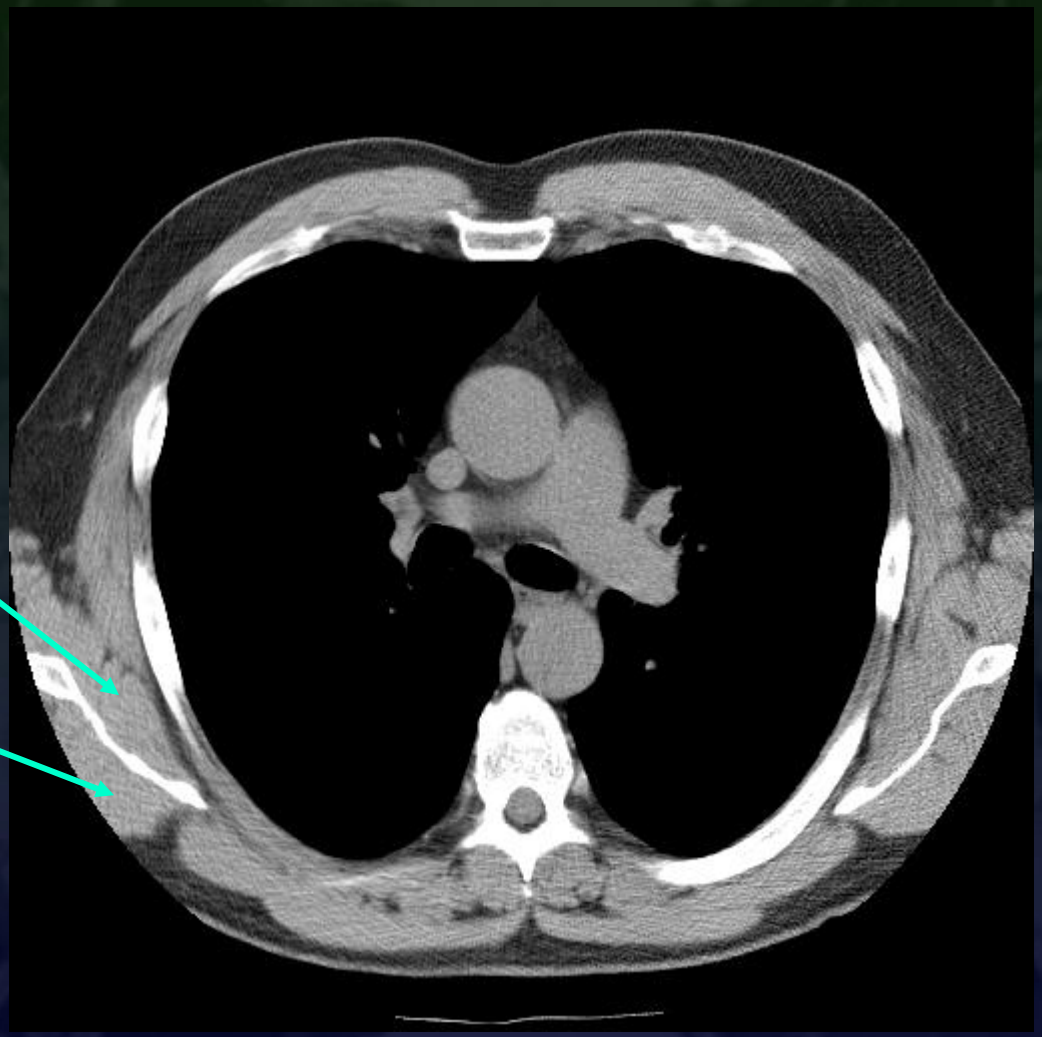


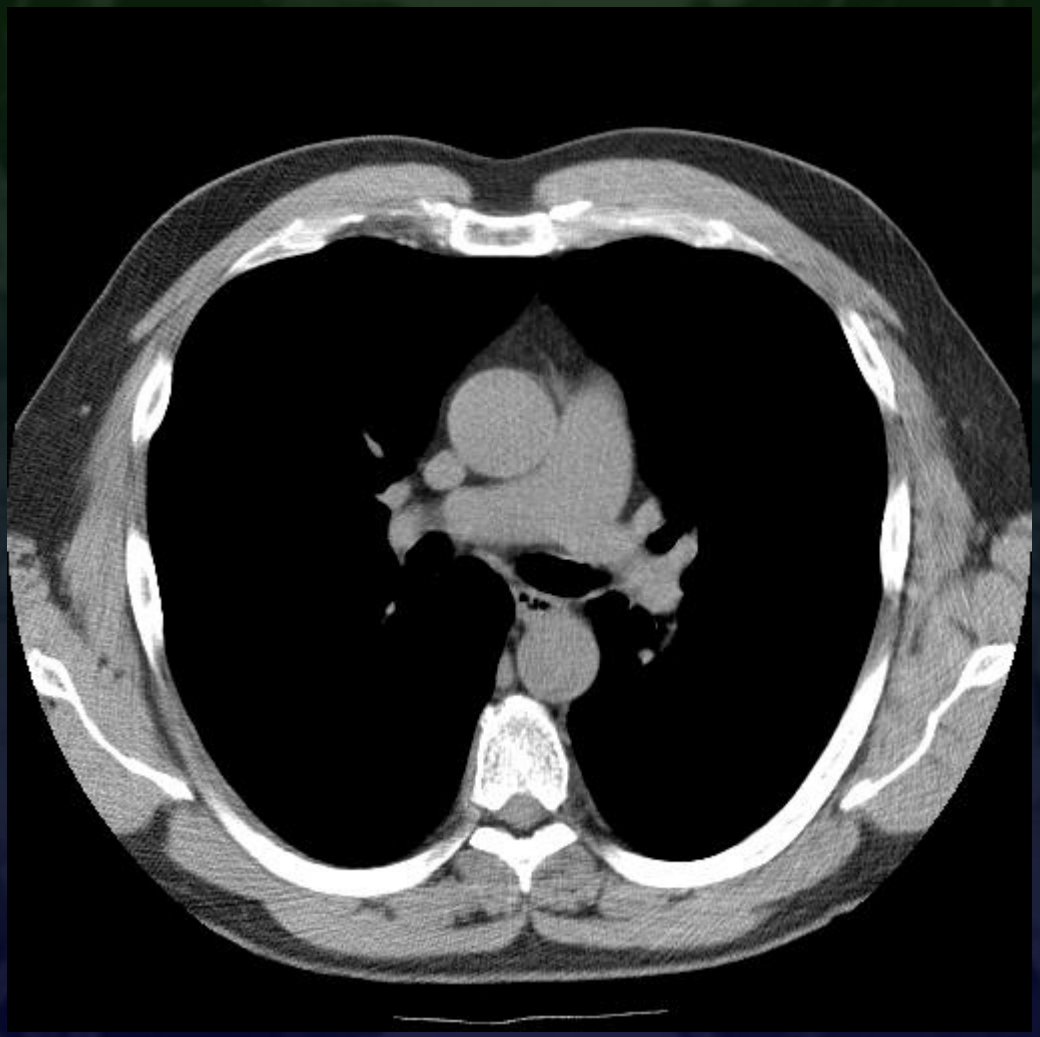


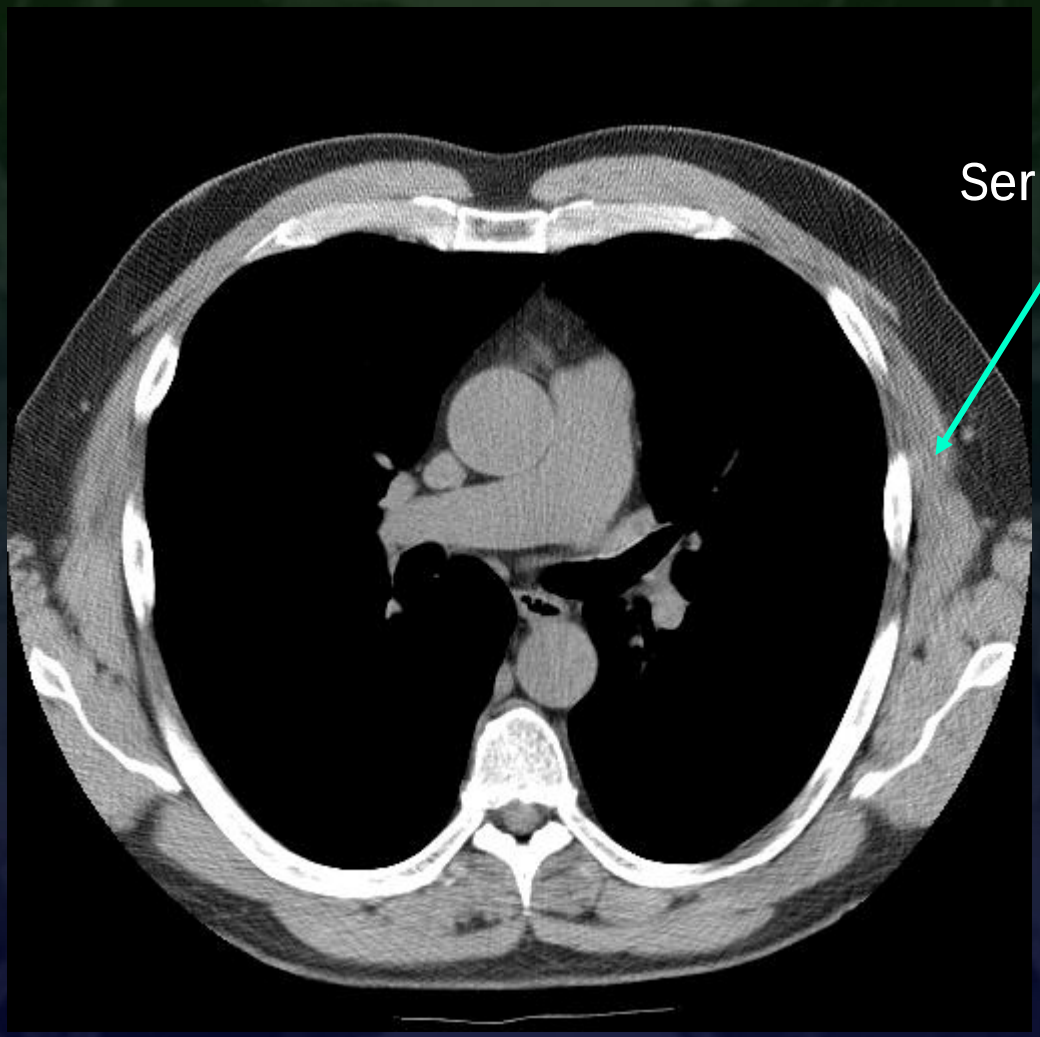


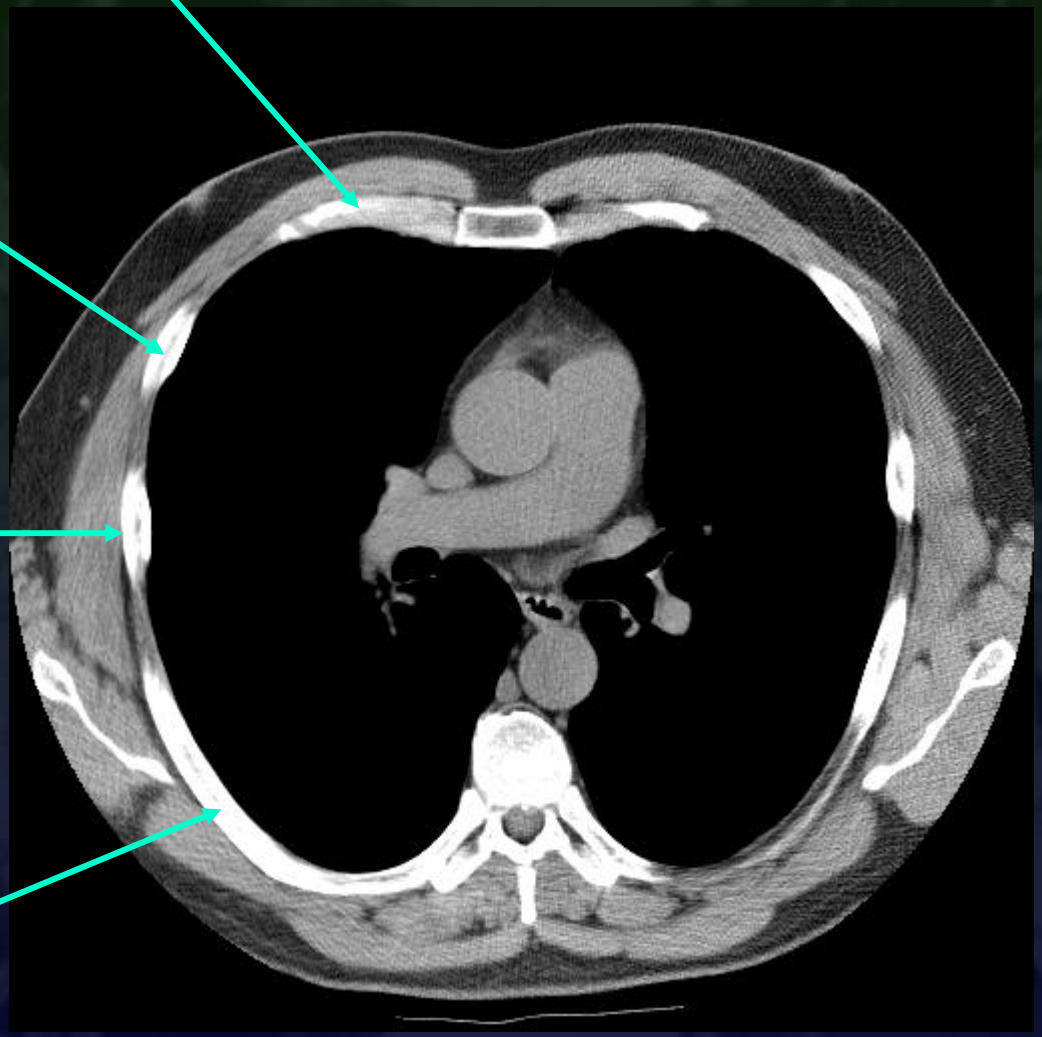
Pectoralis Major




Subscapularis
Infraspinatus




Serratus Anterior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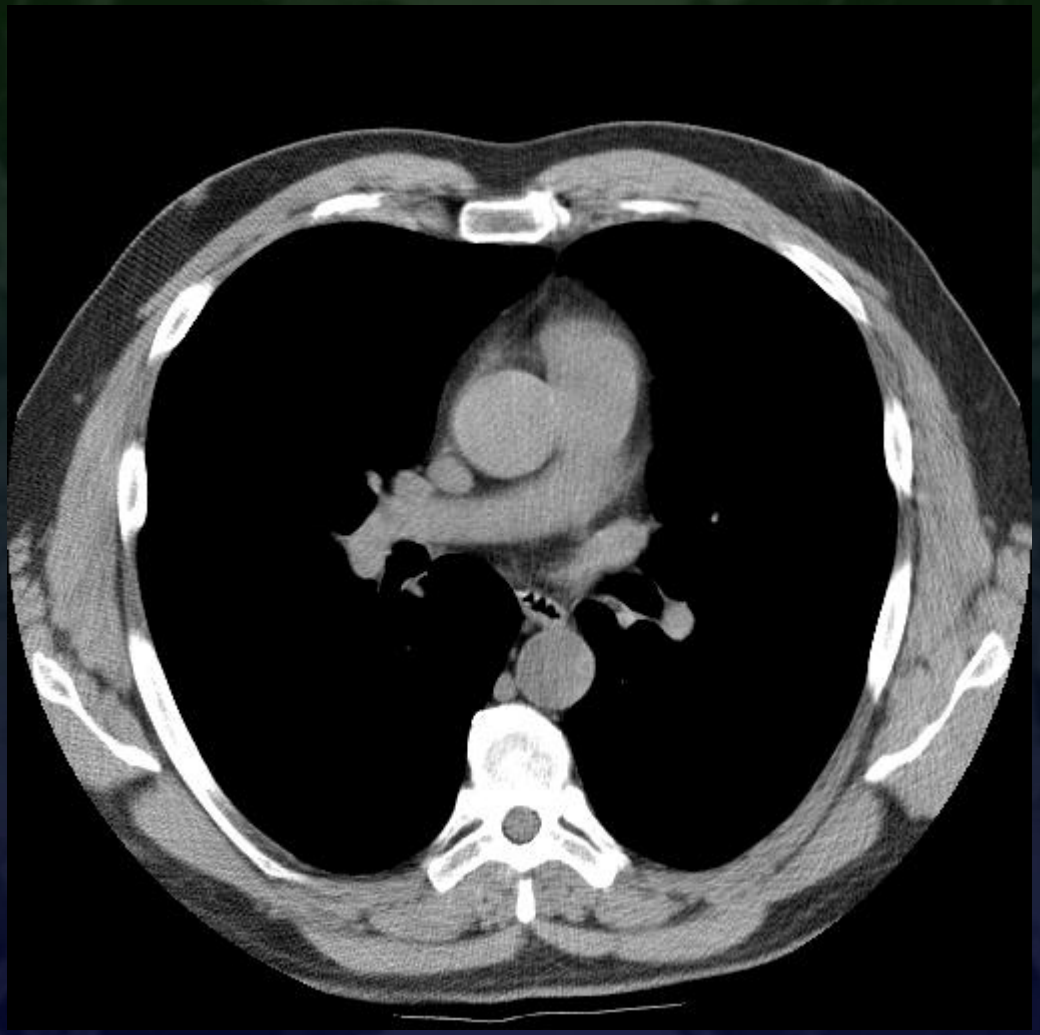

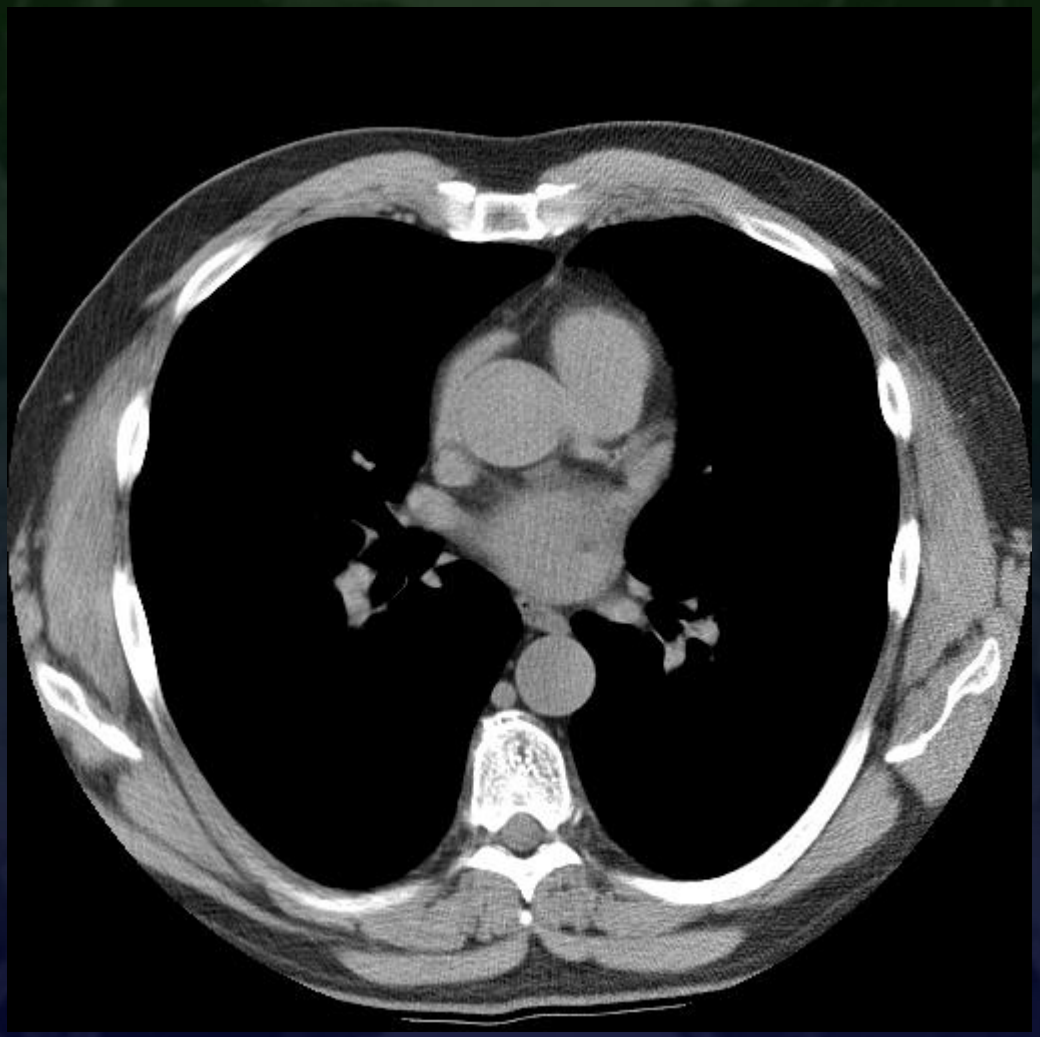

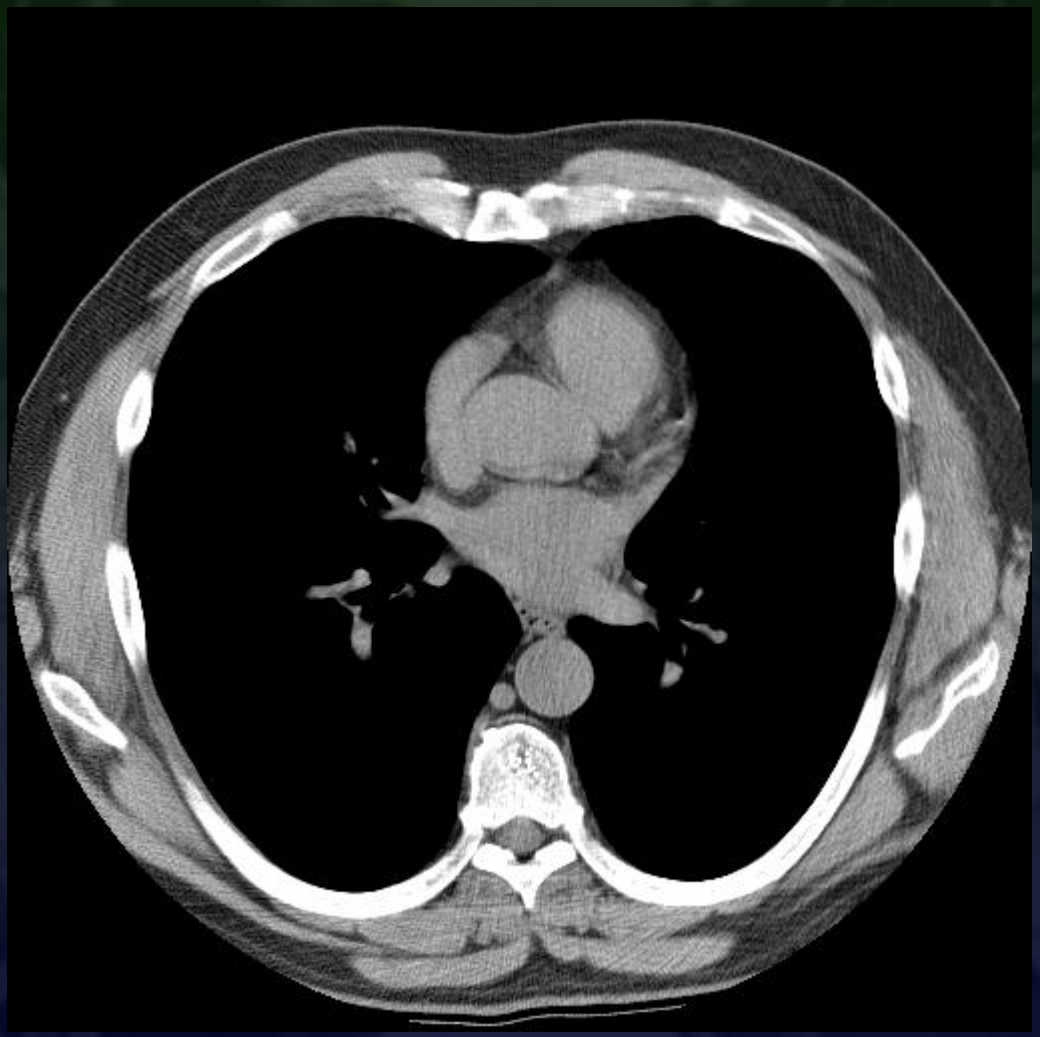

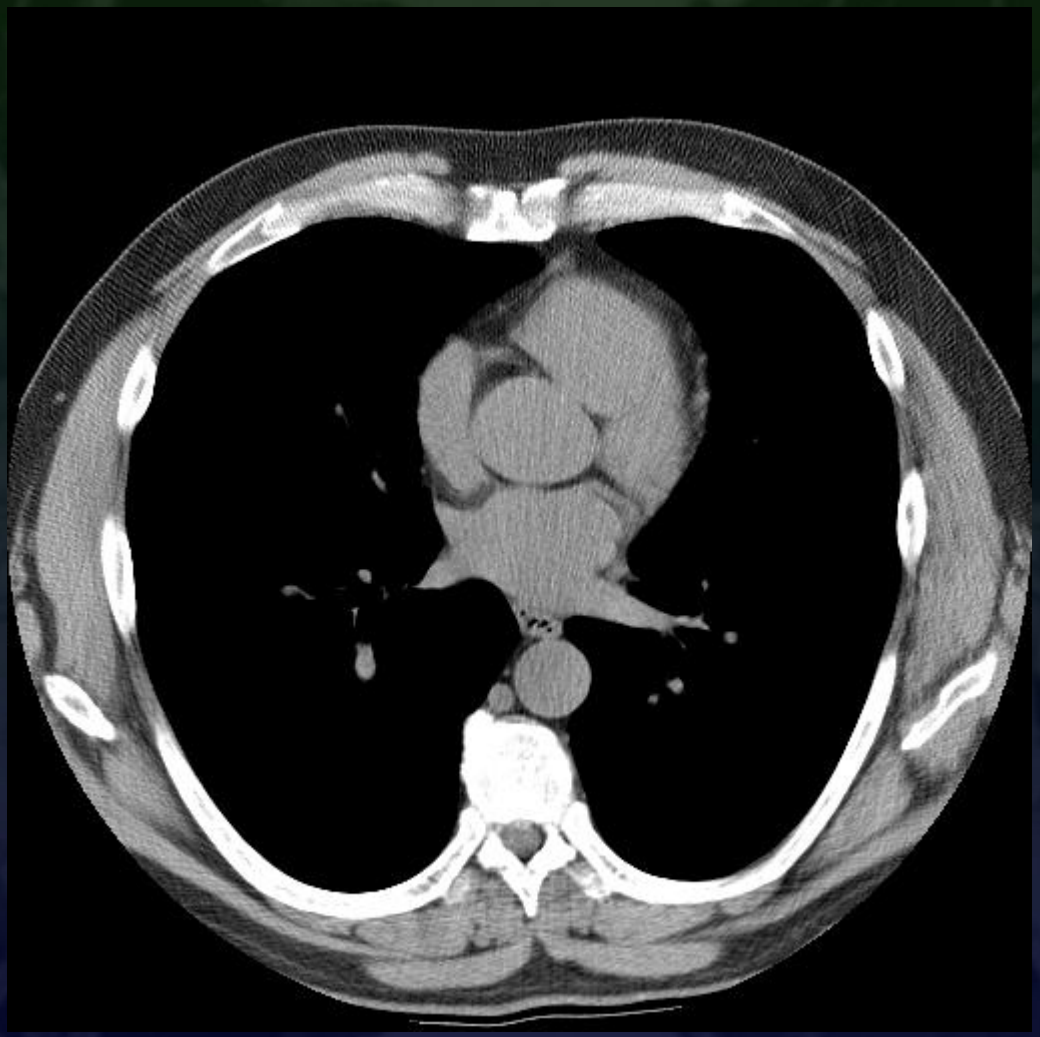

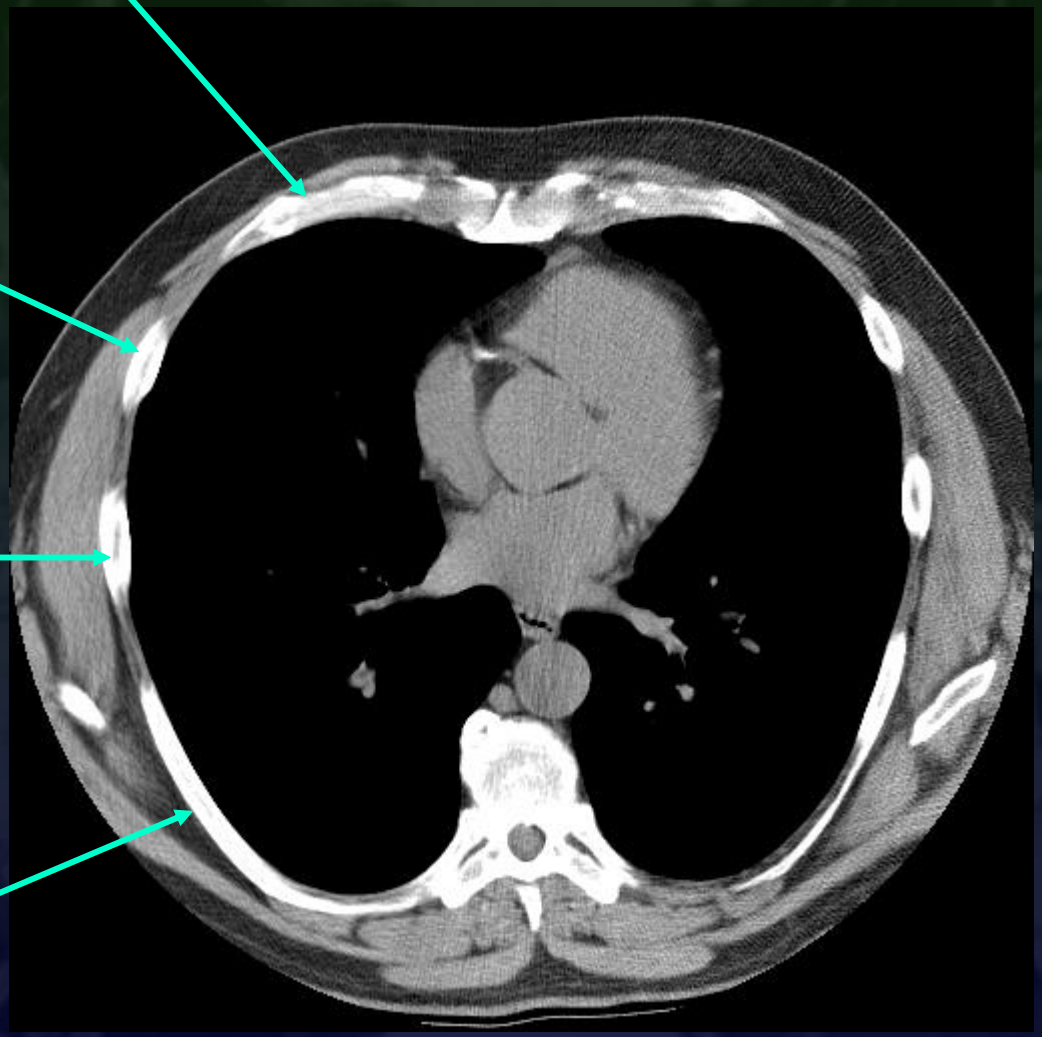
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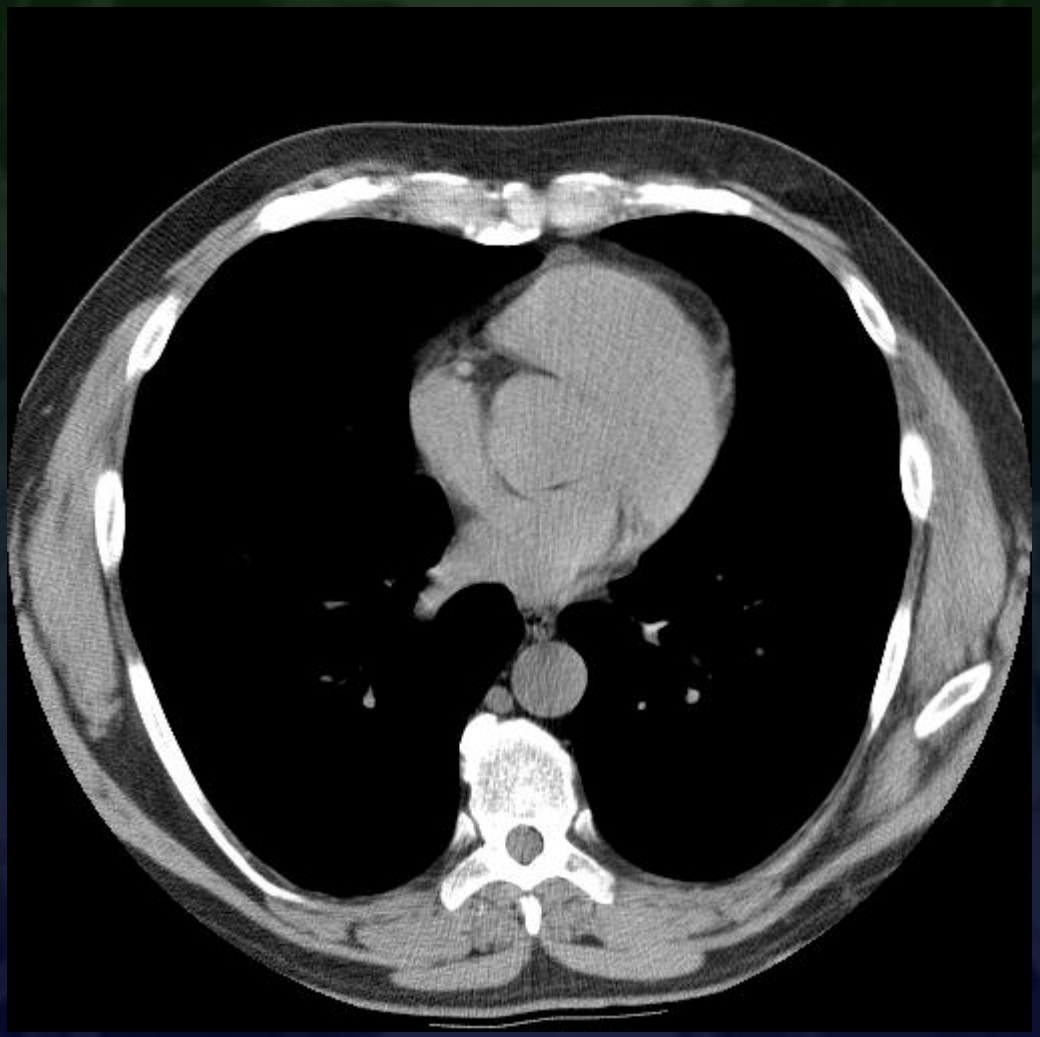
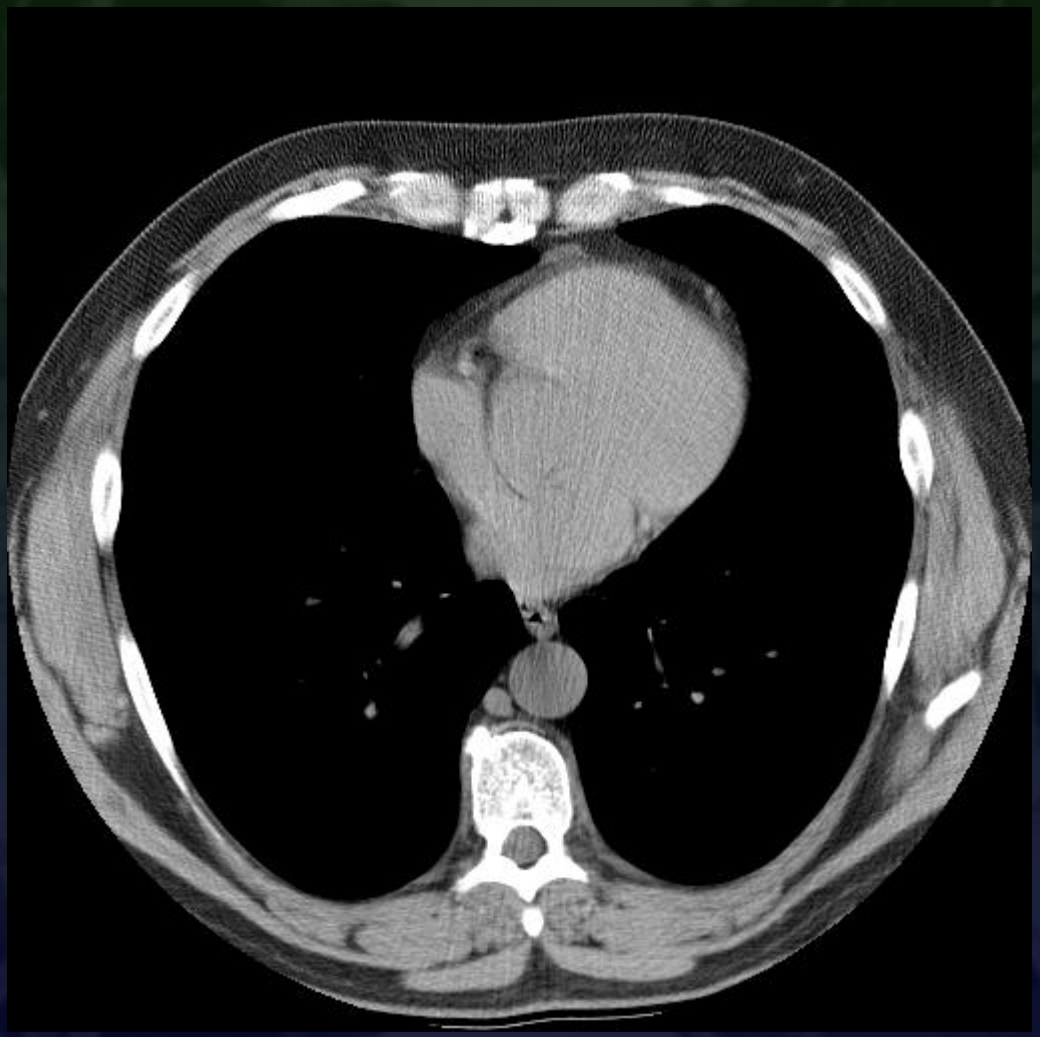
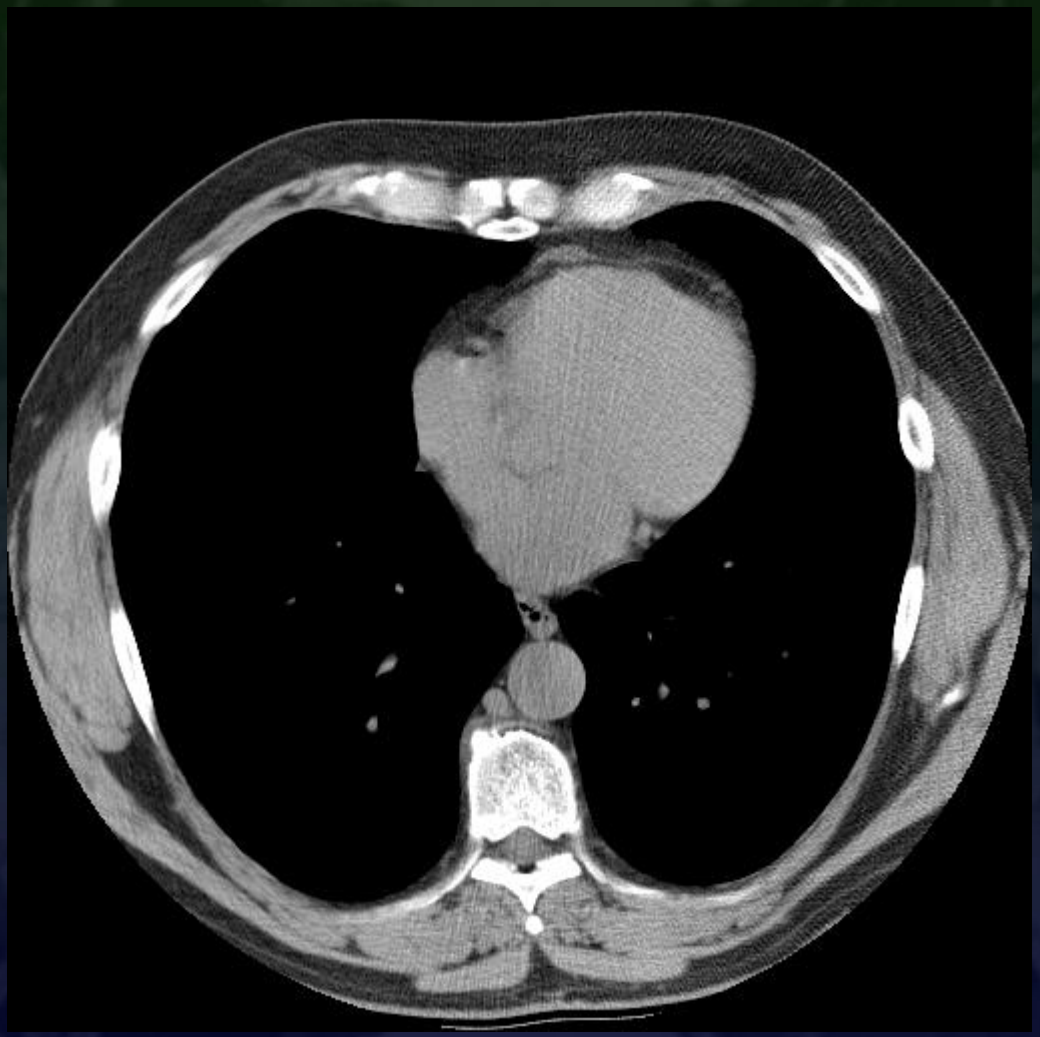
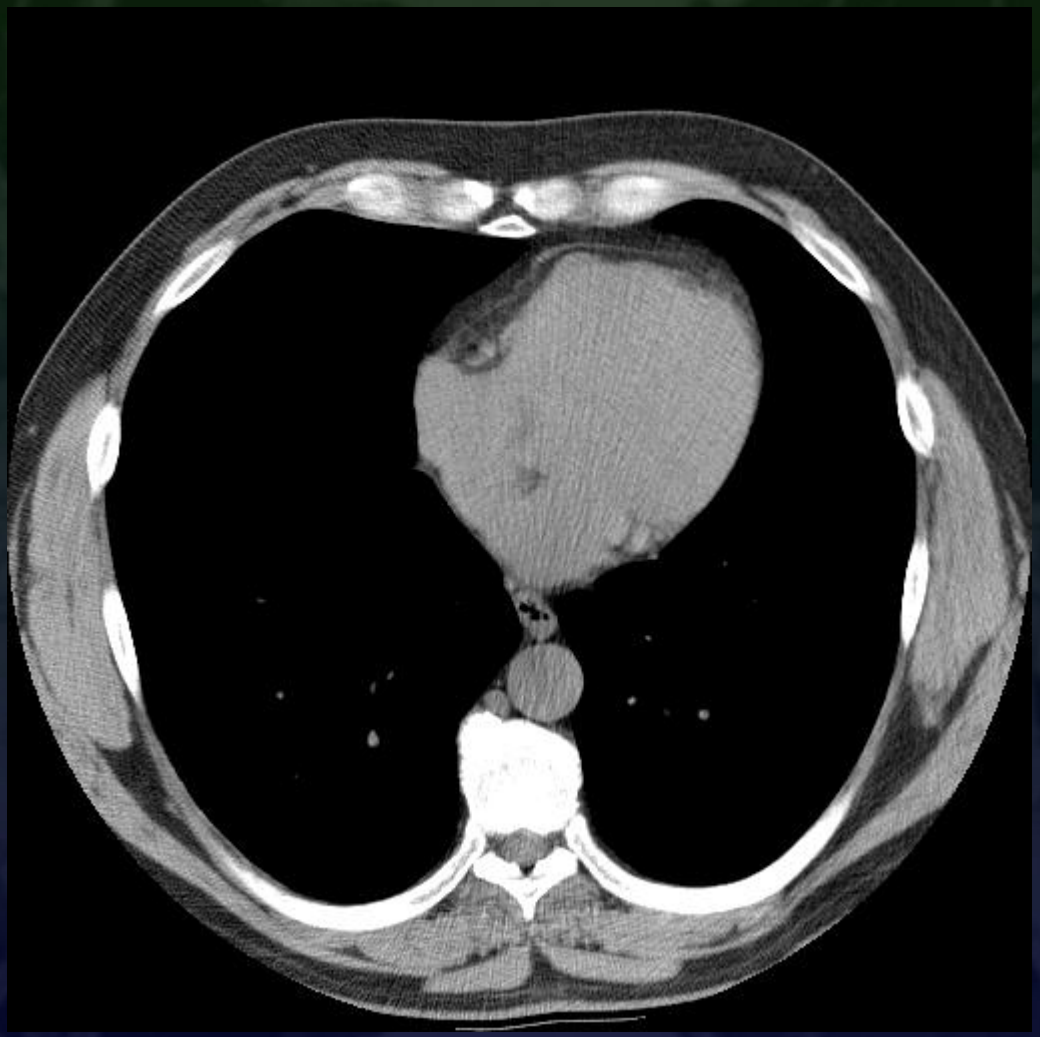
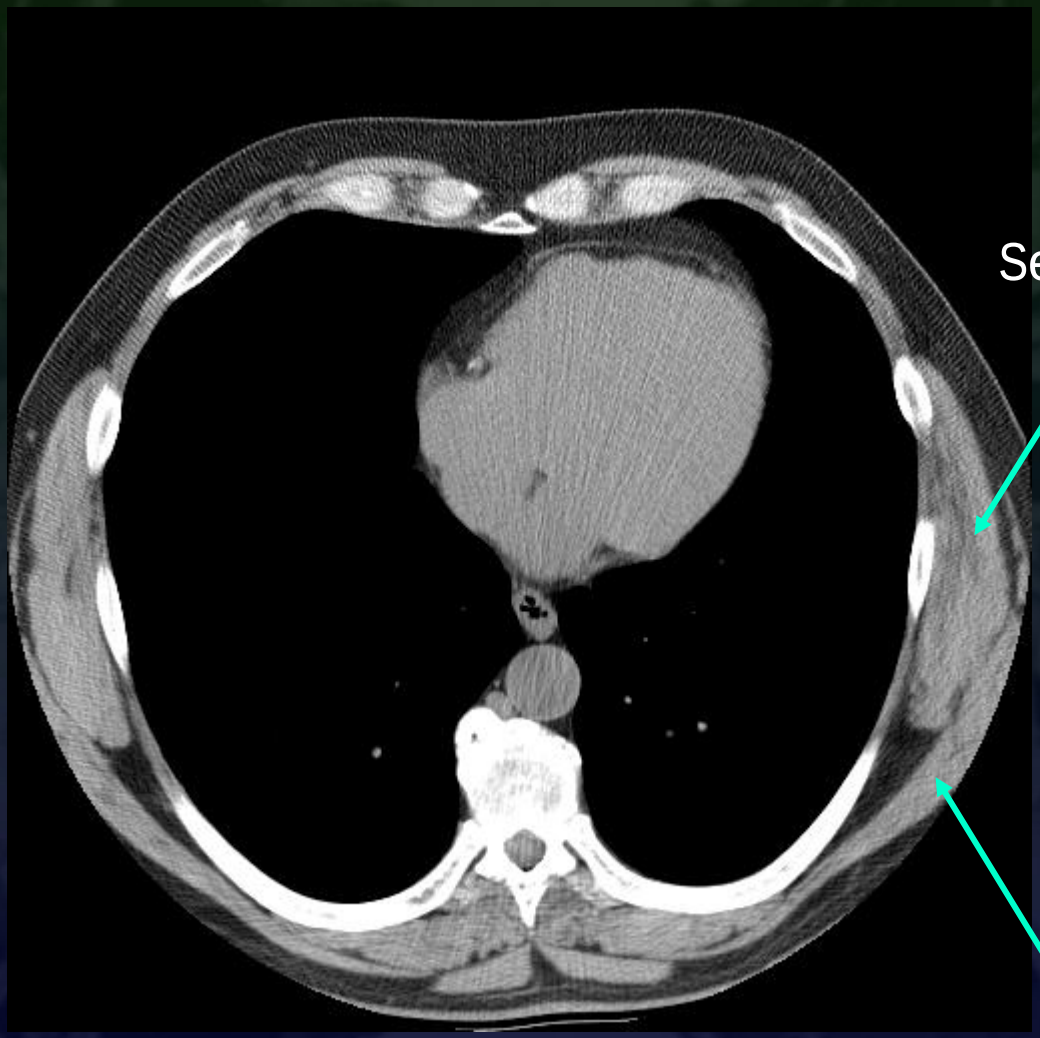
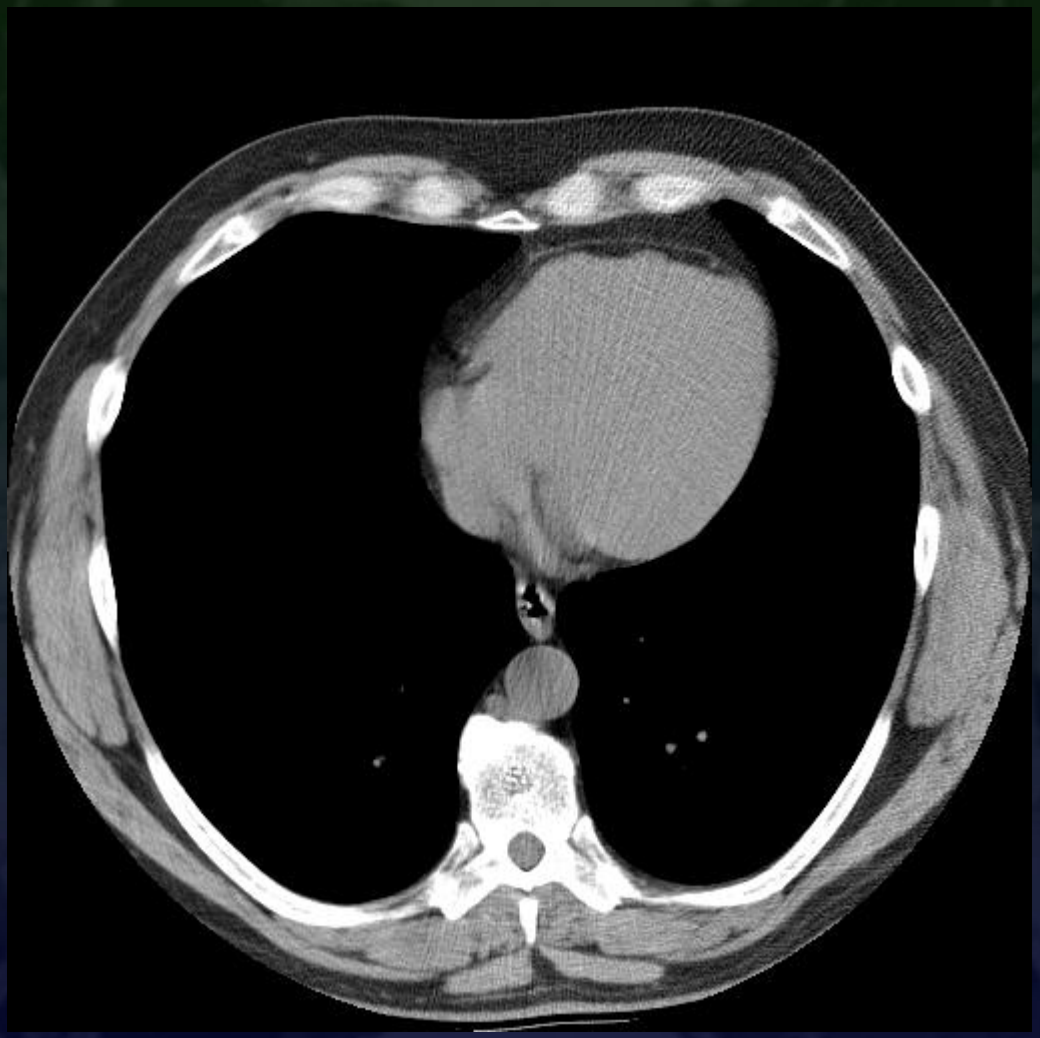


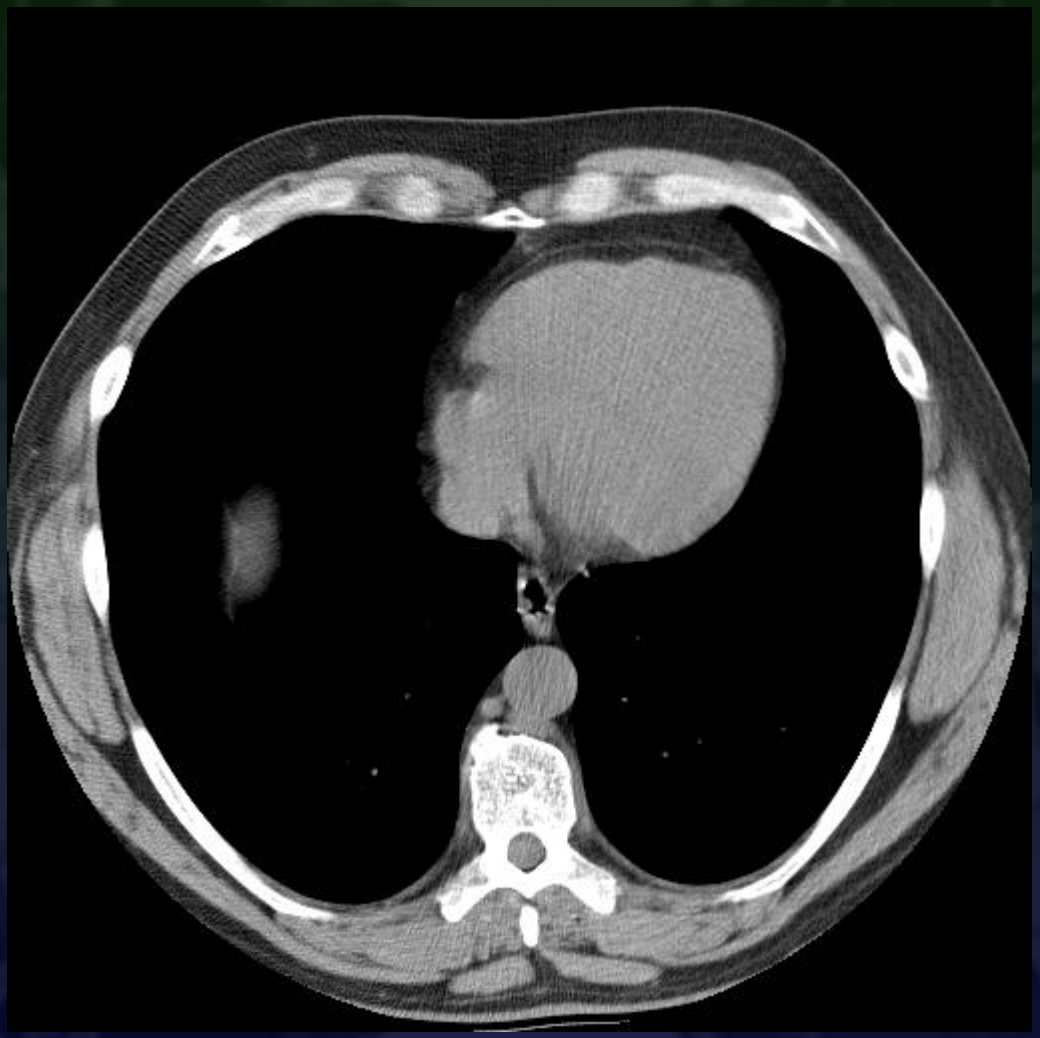


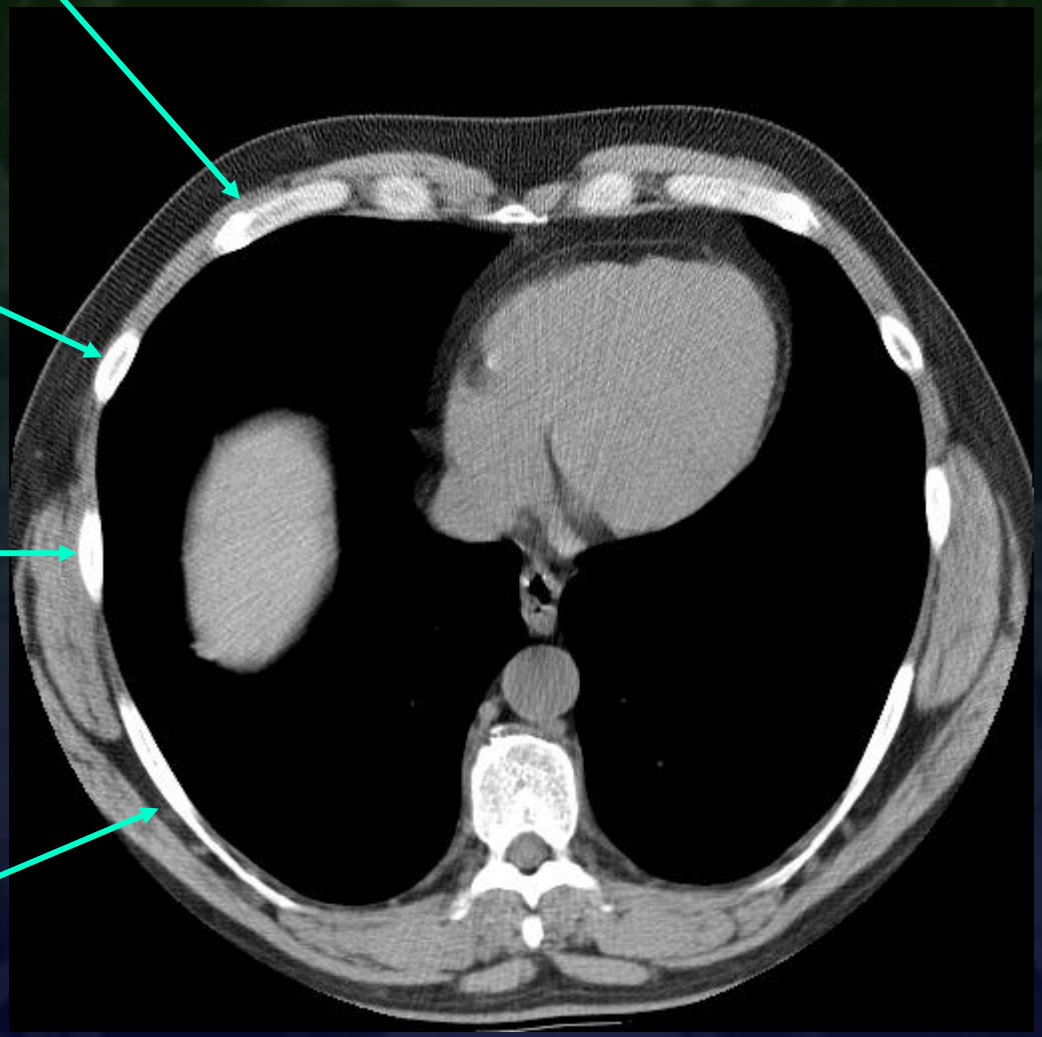





Serratus Anterior
Latissimus Dorsi



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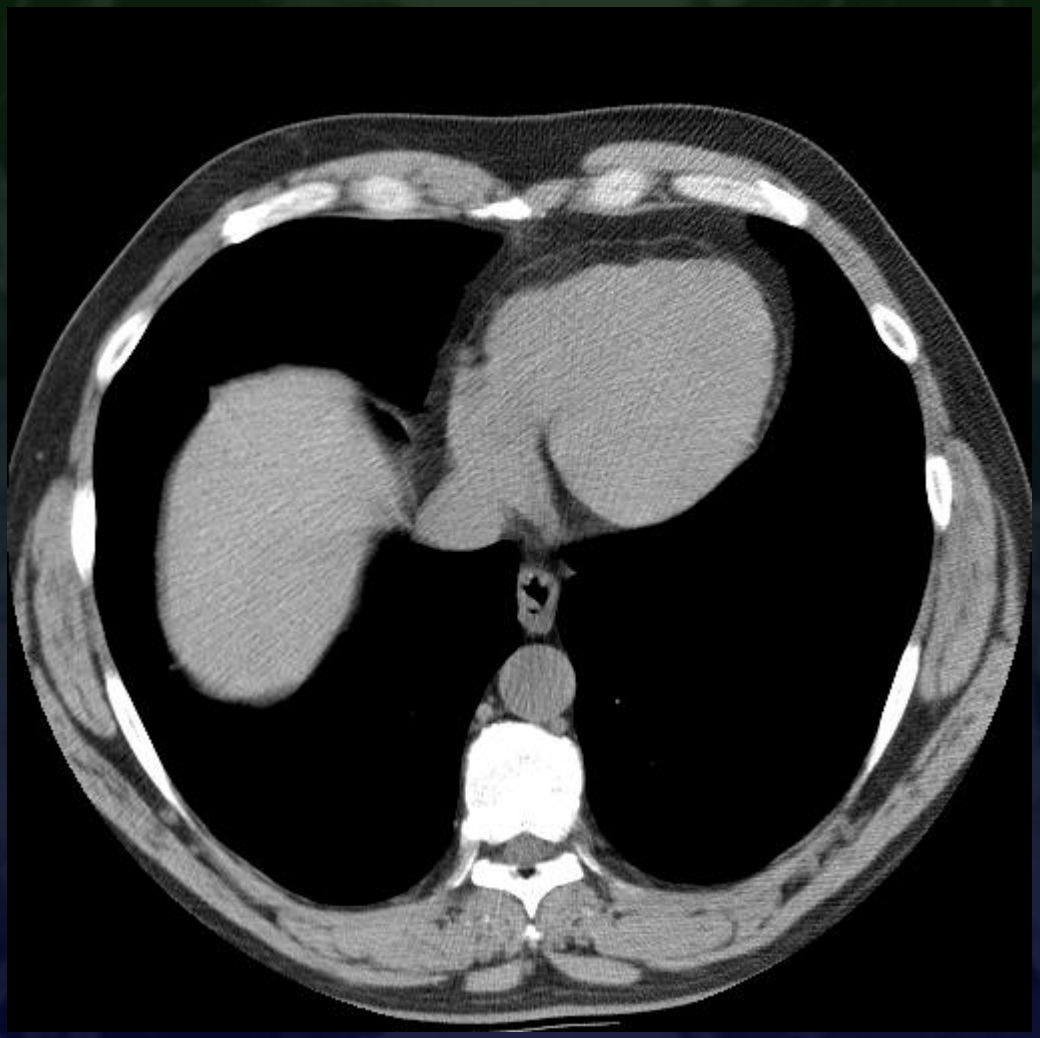

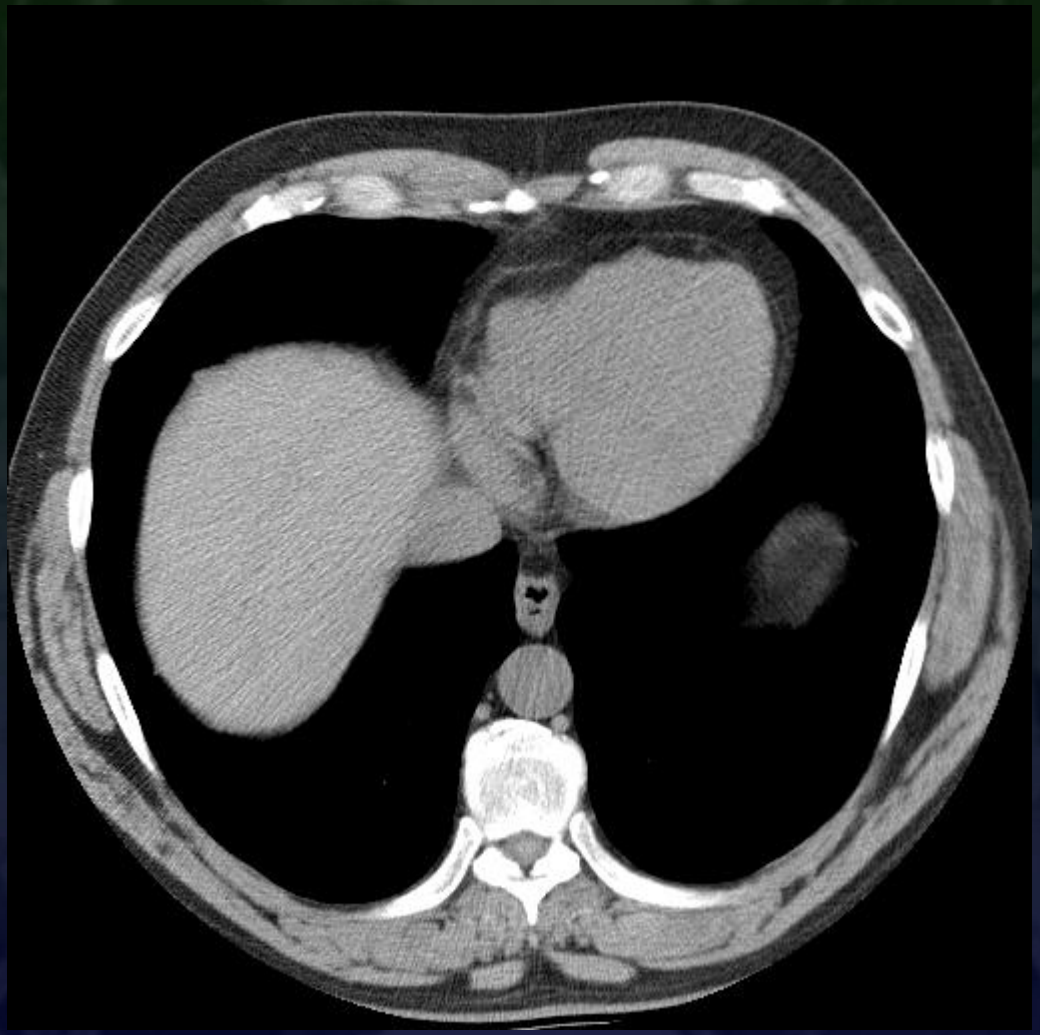

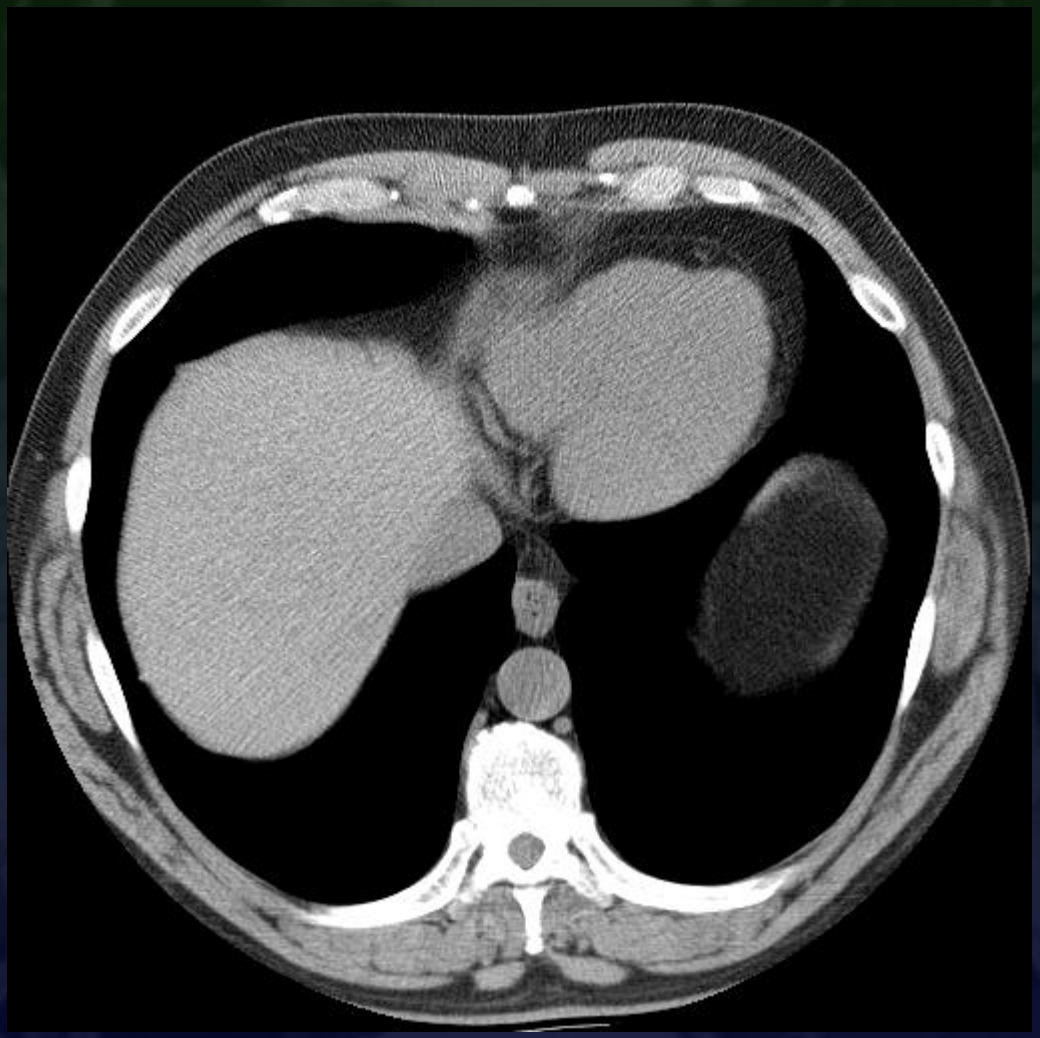

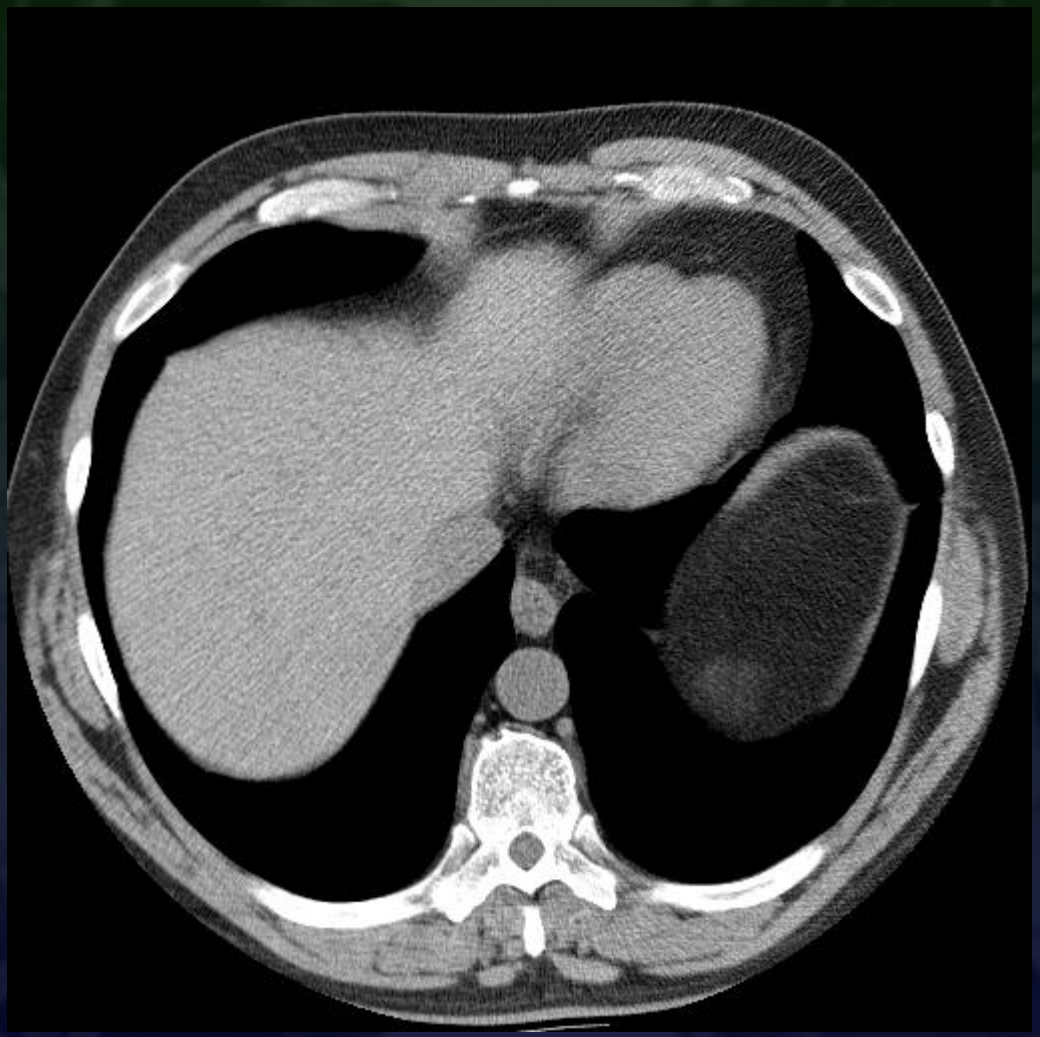

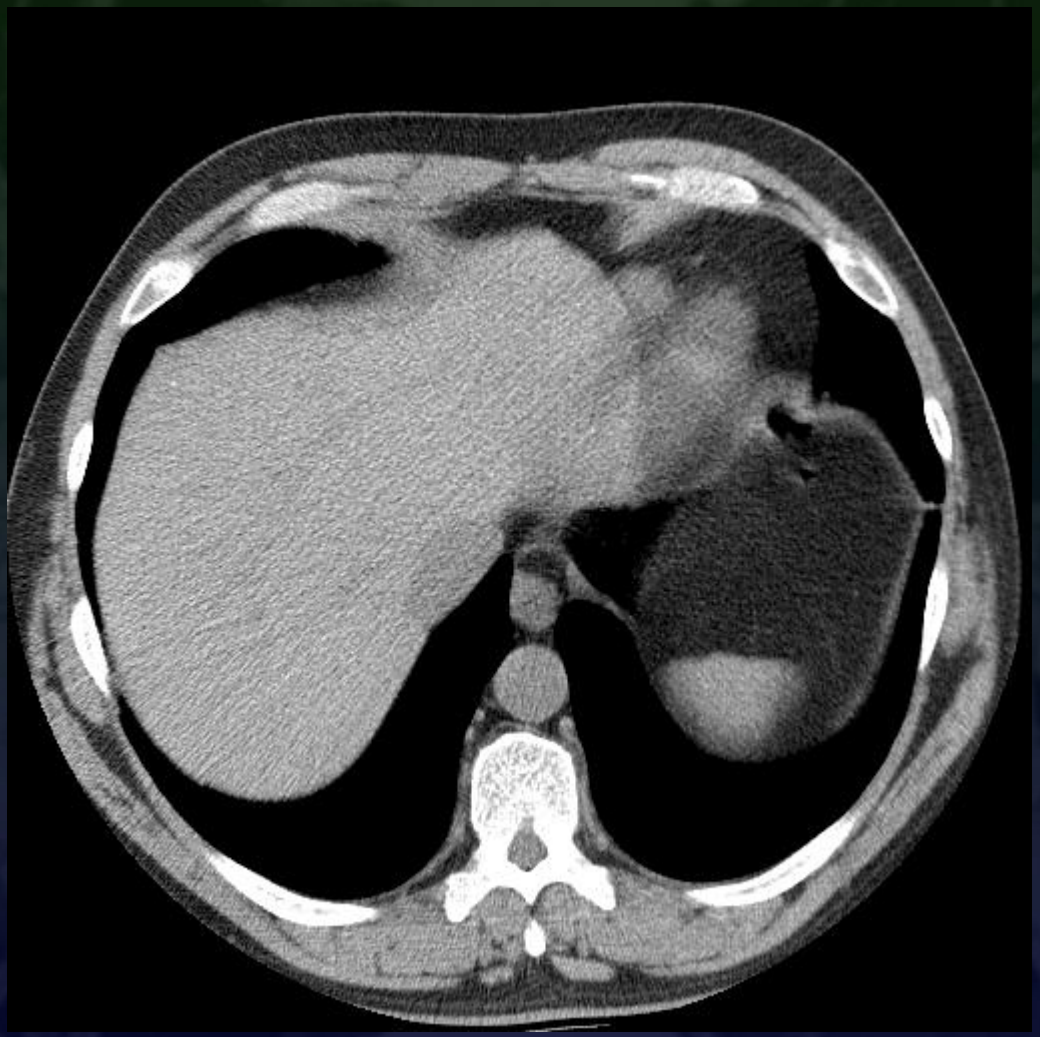

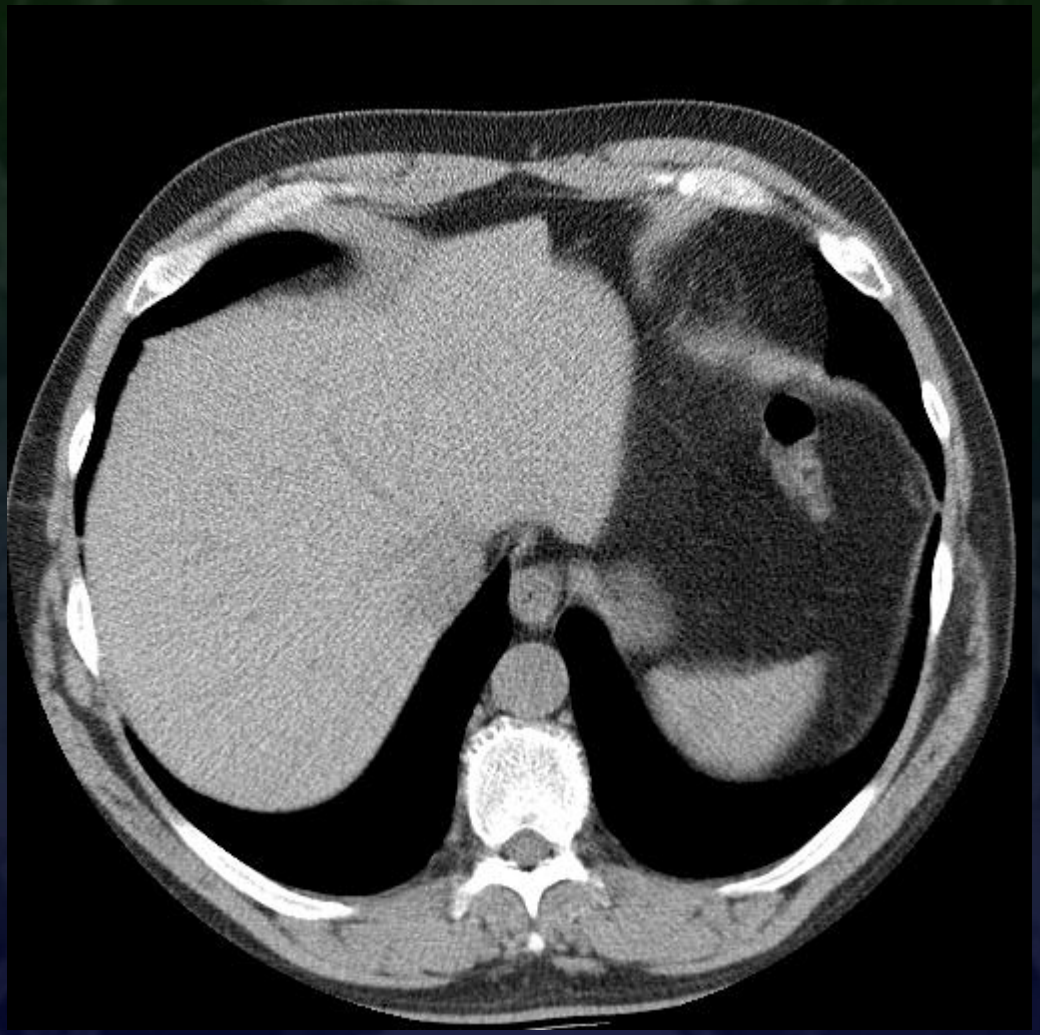

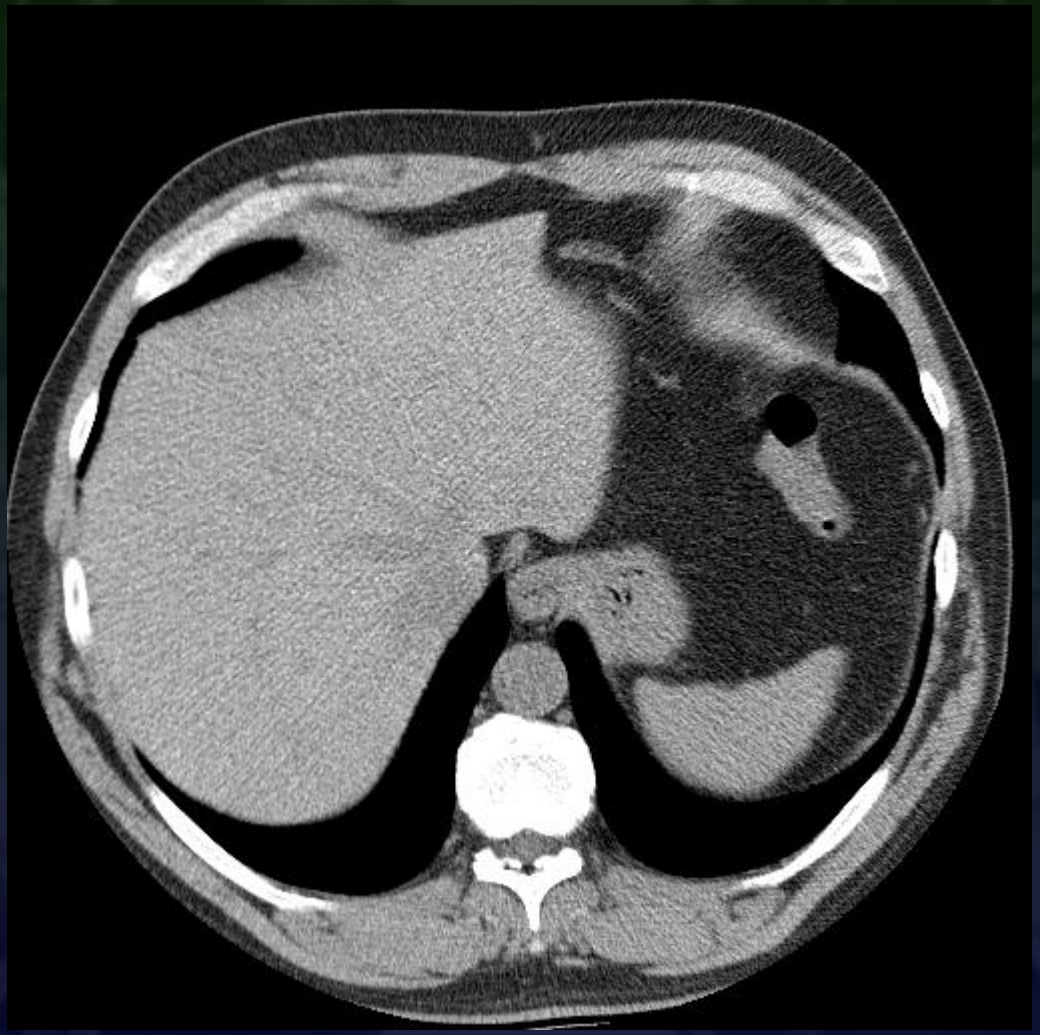

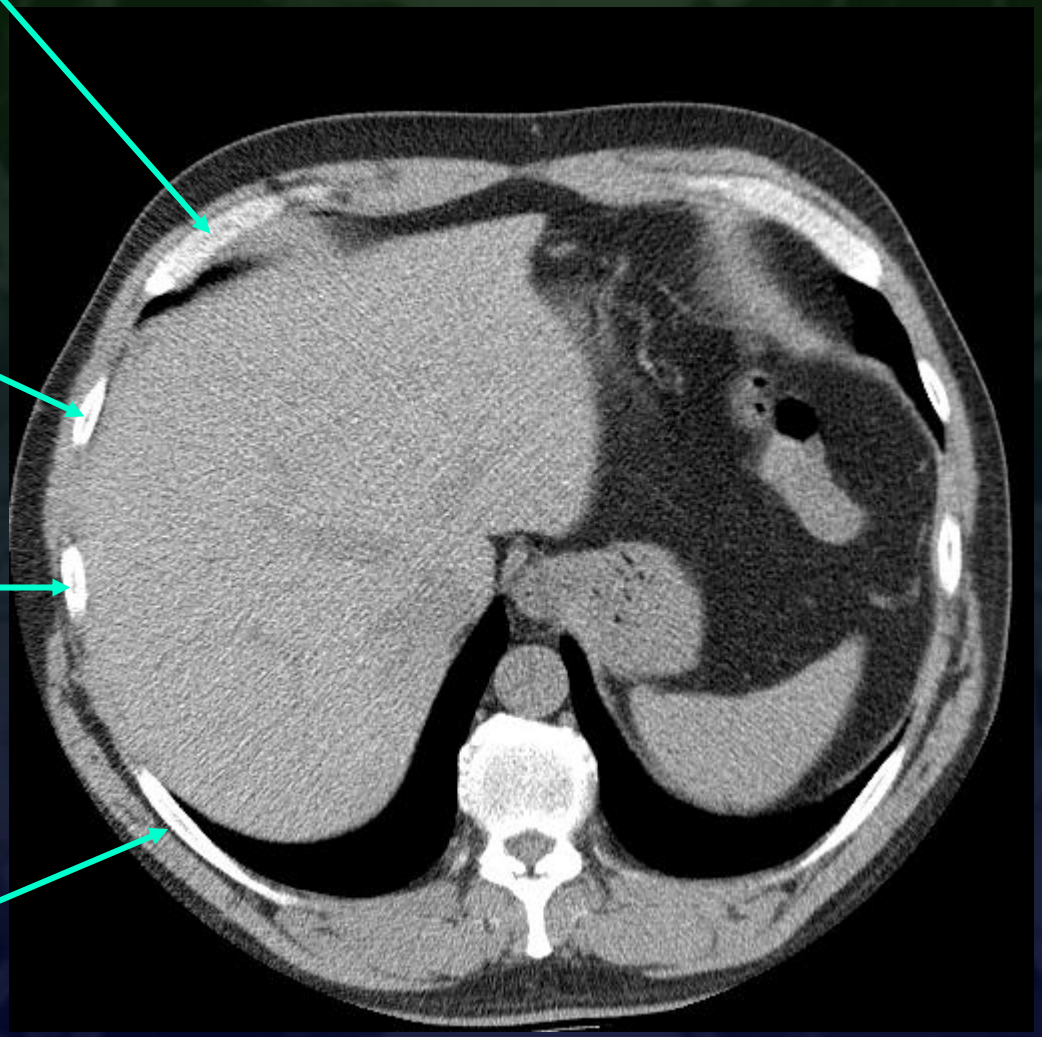
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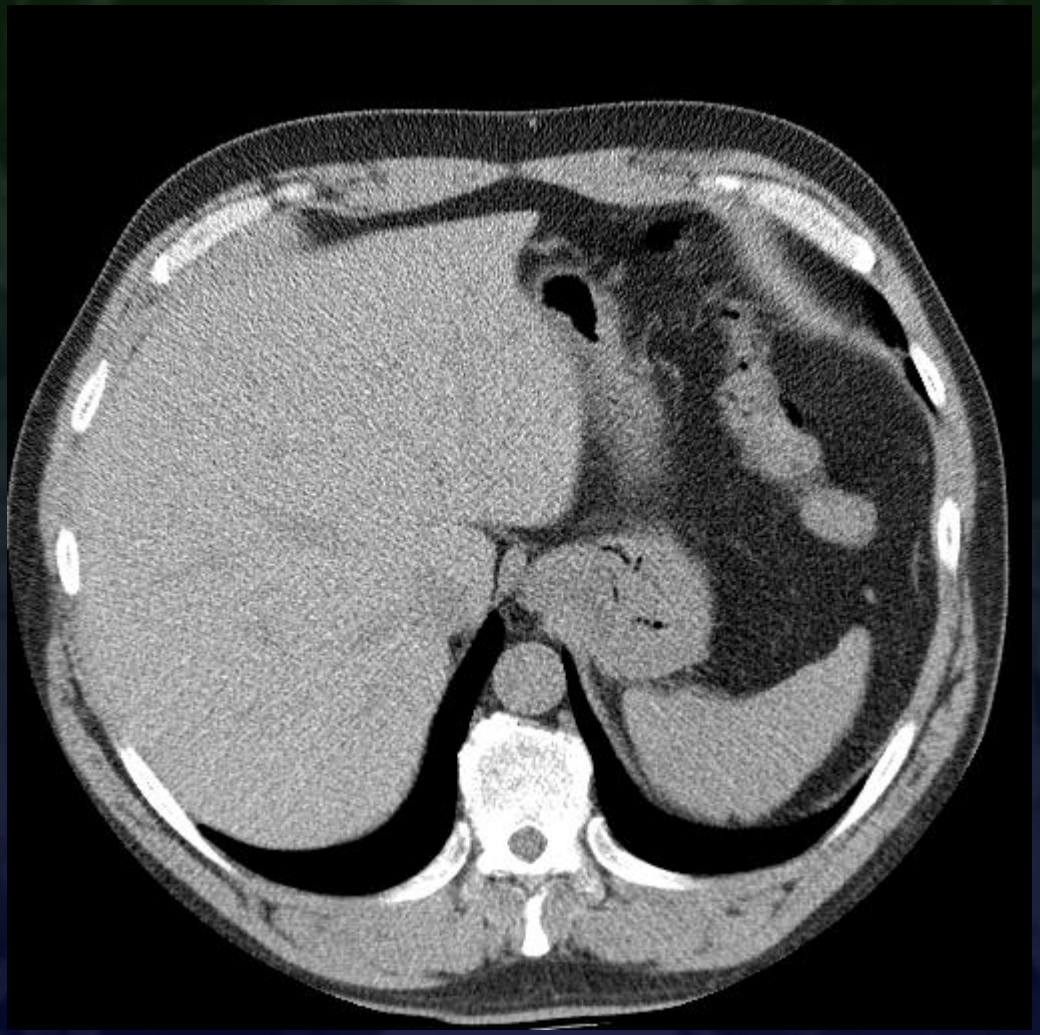

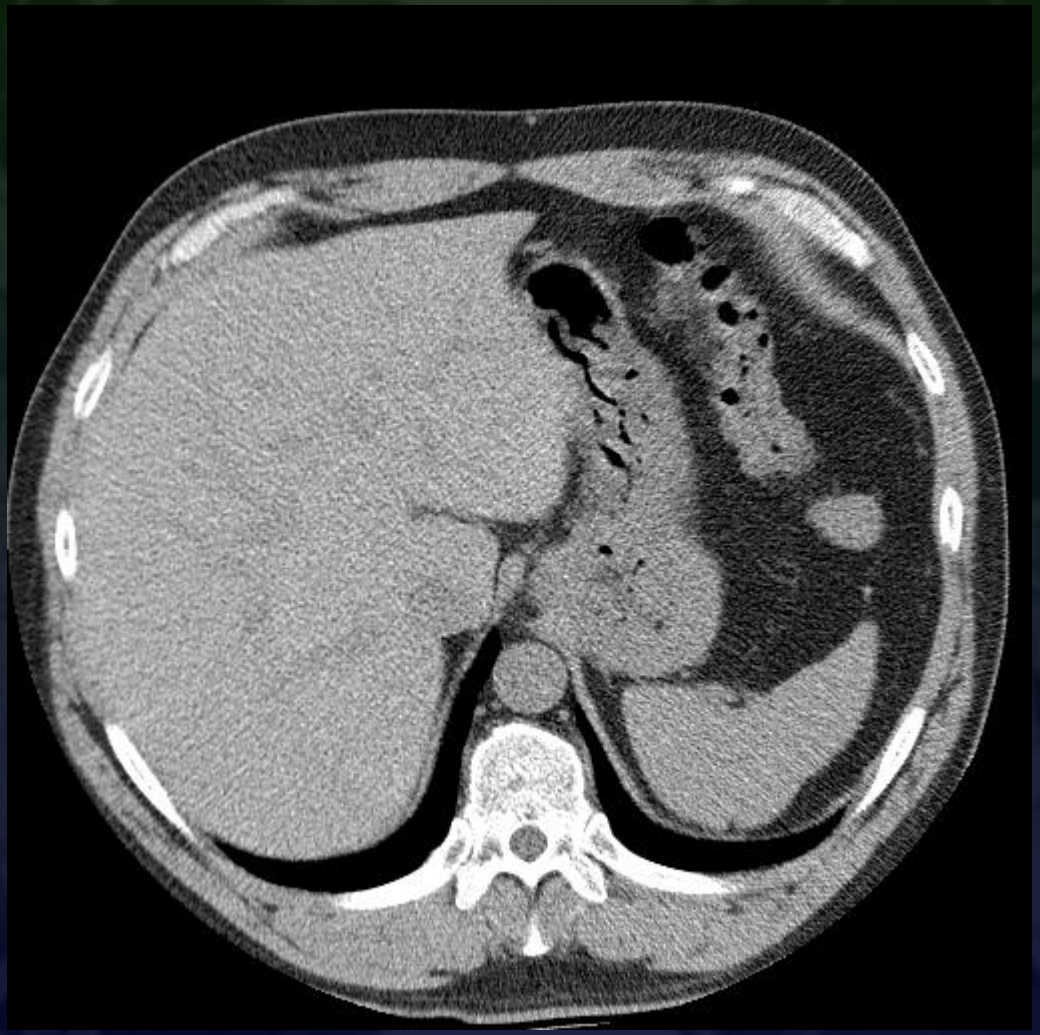

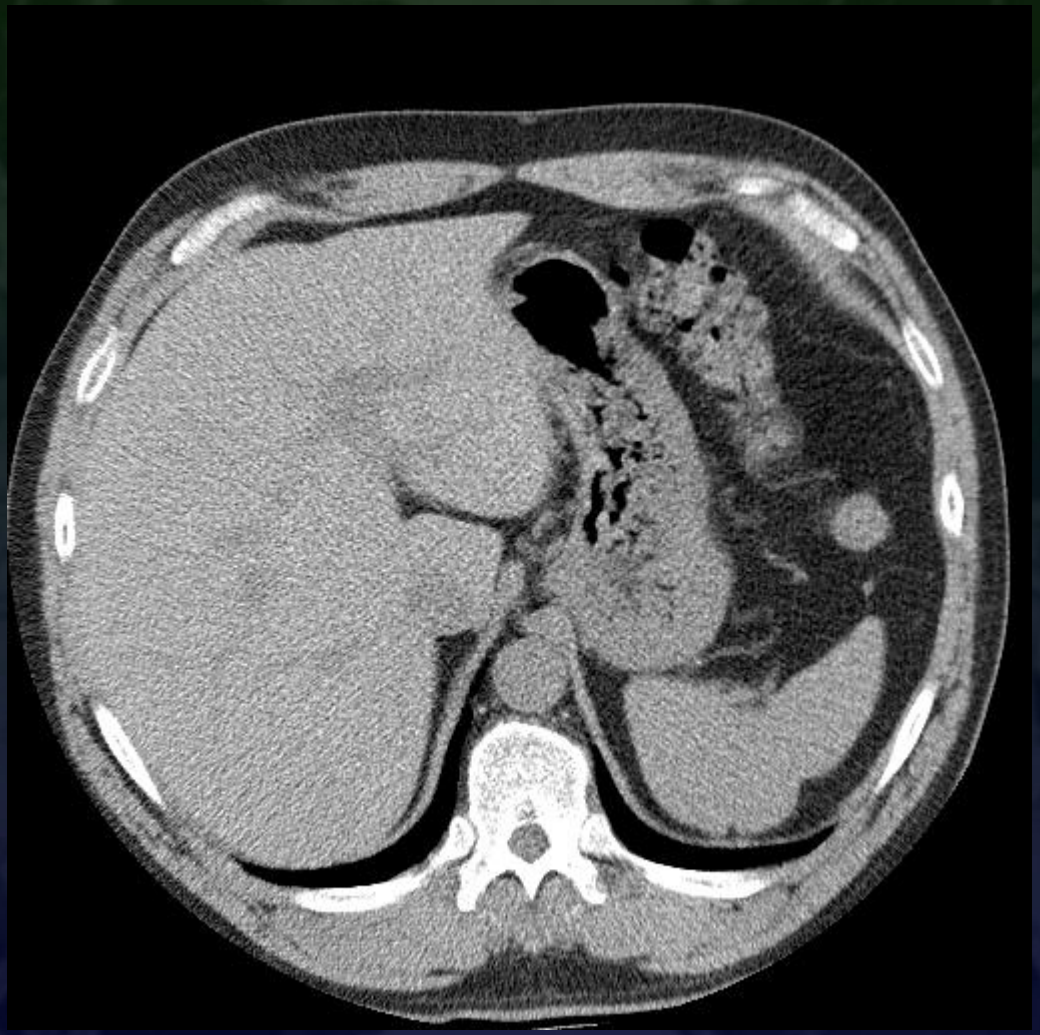

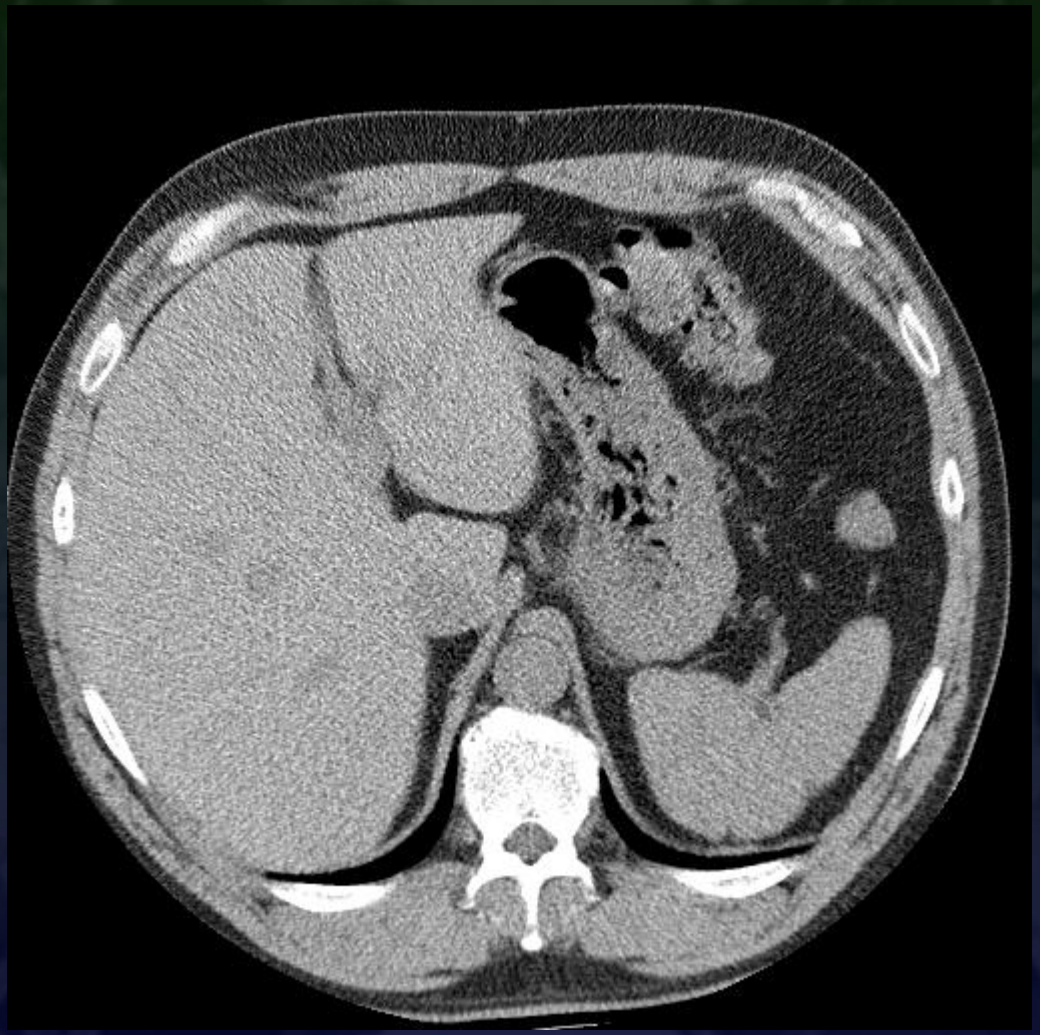

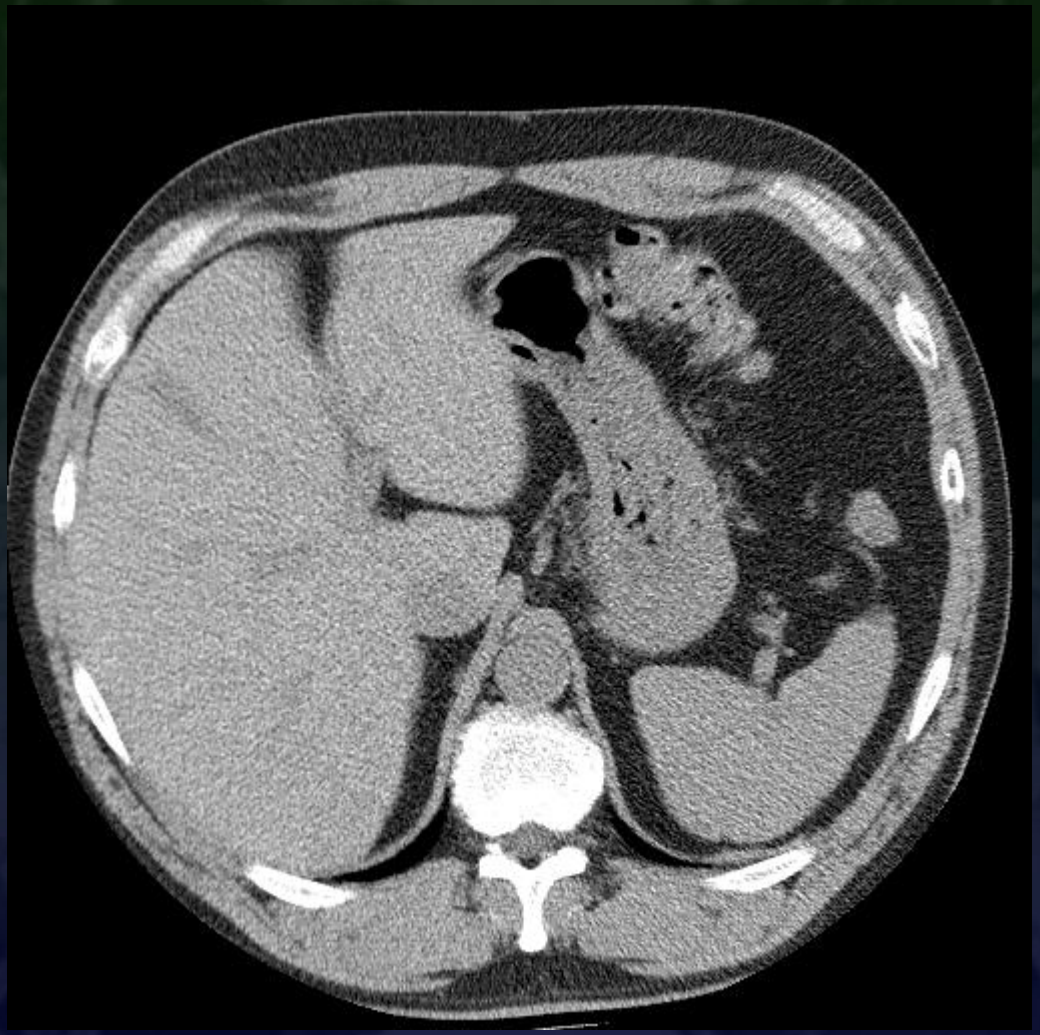

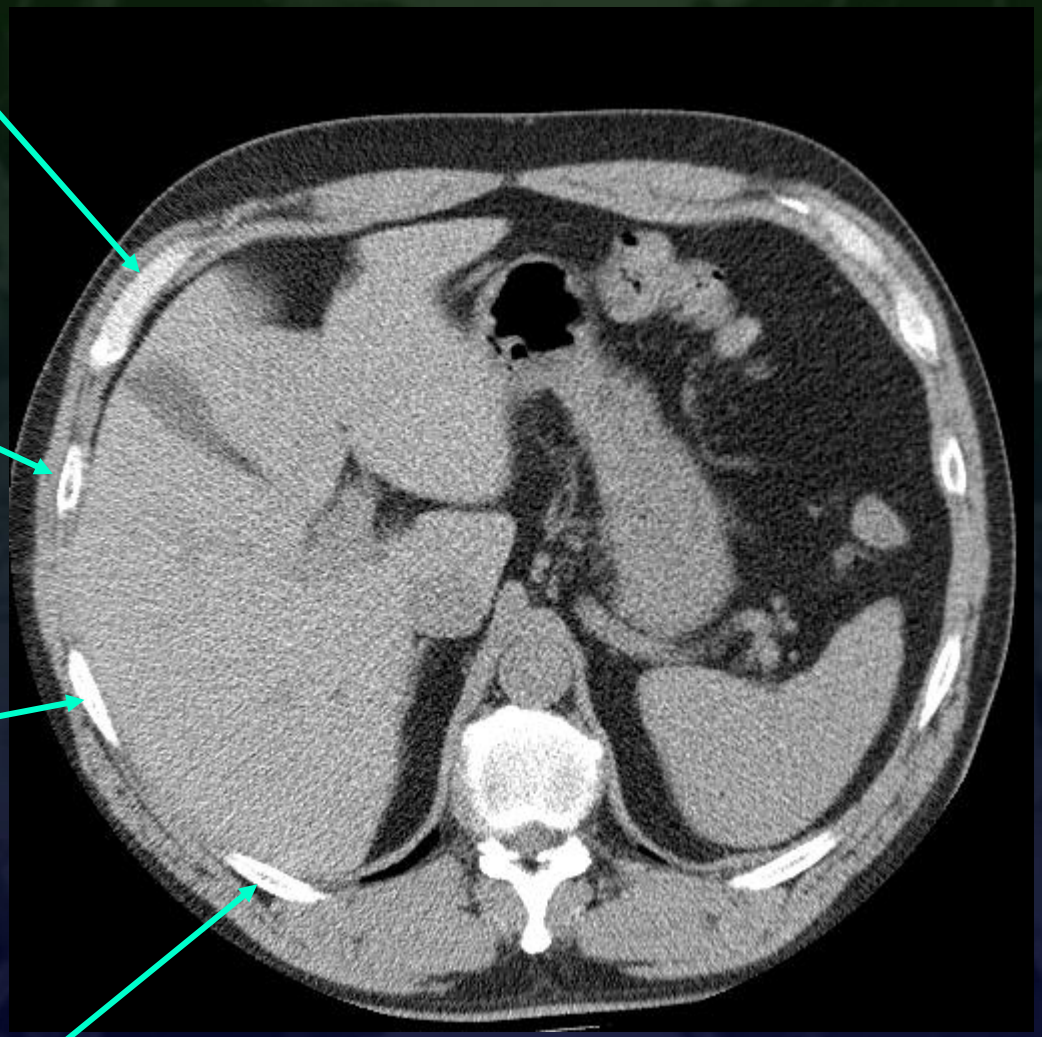
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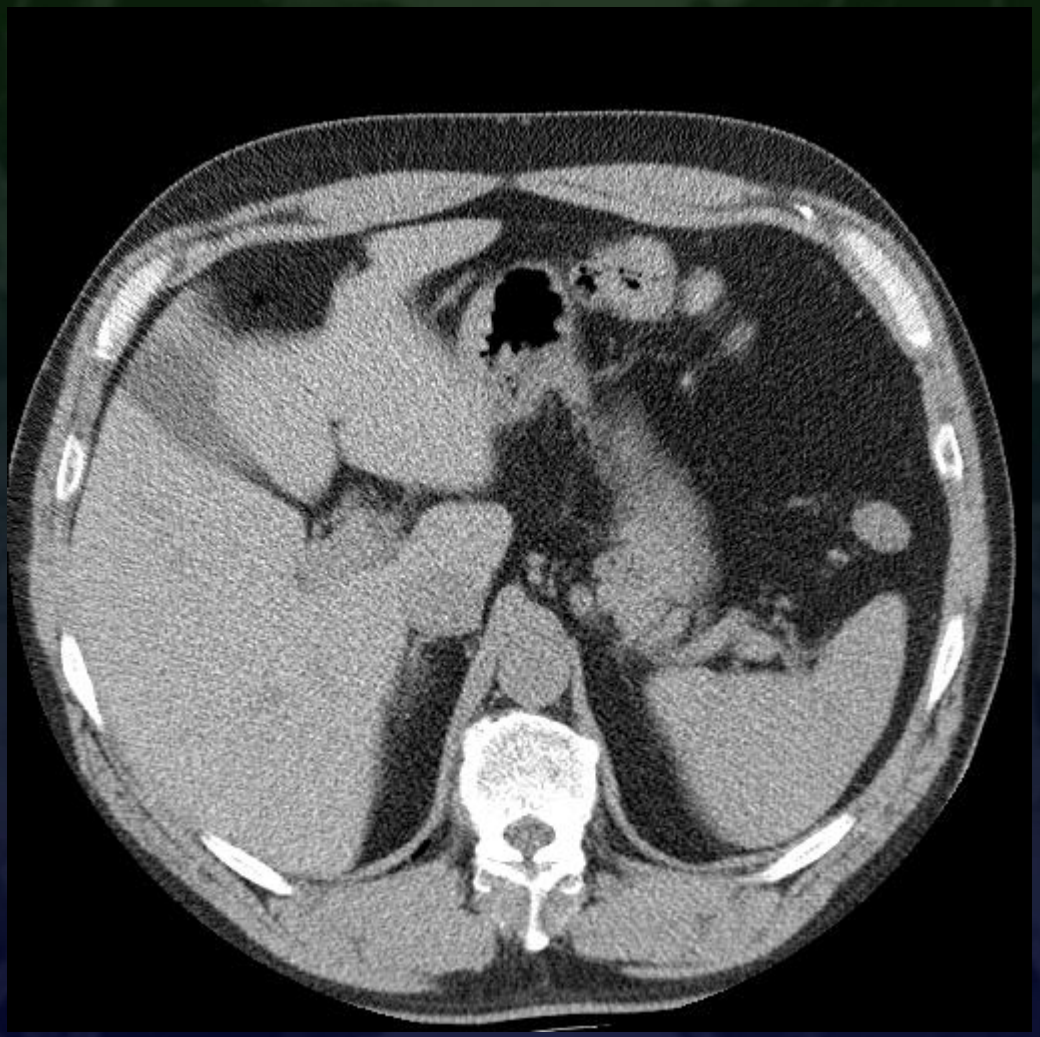

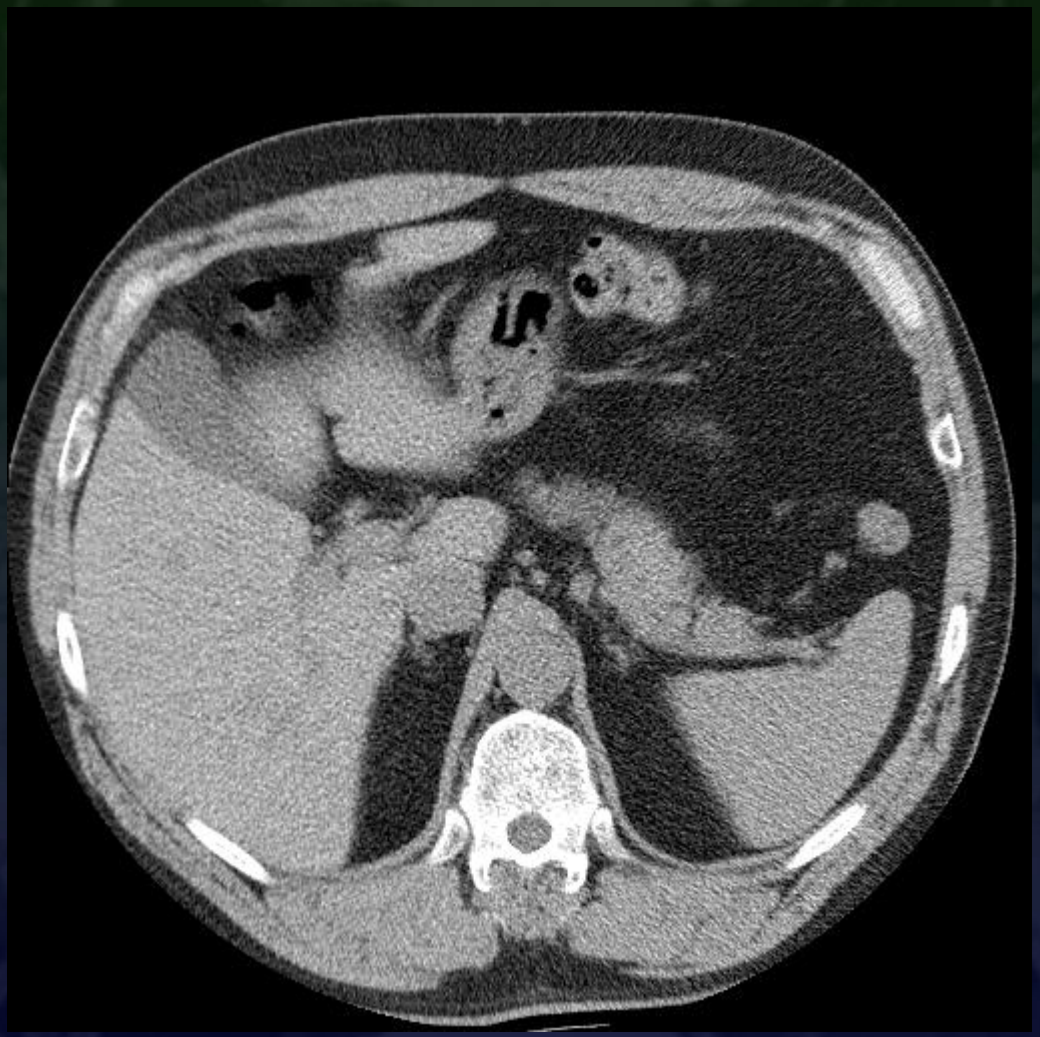

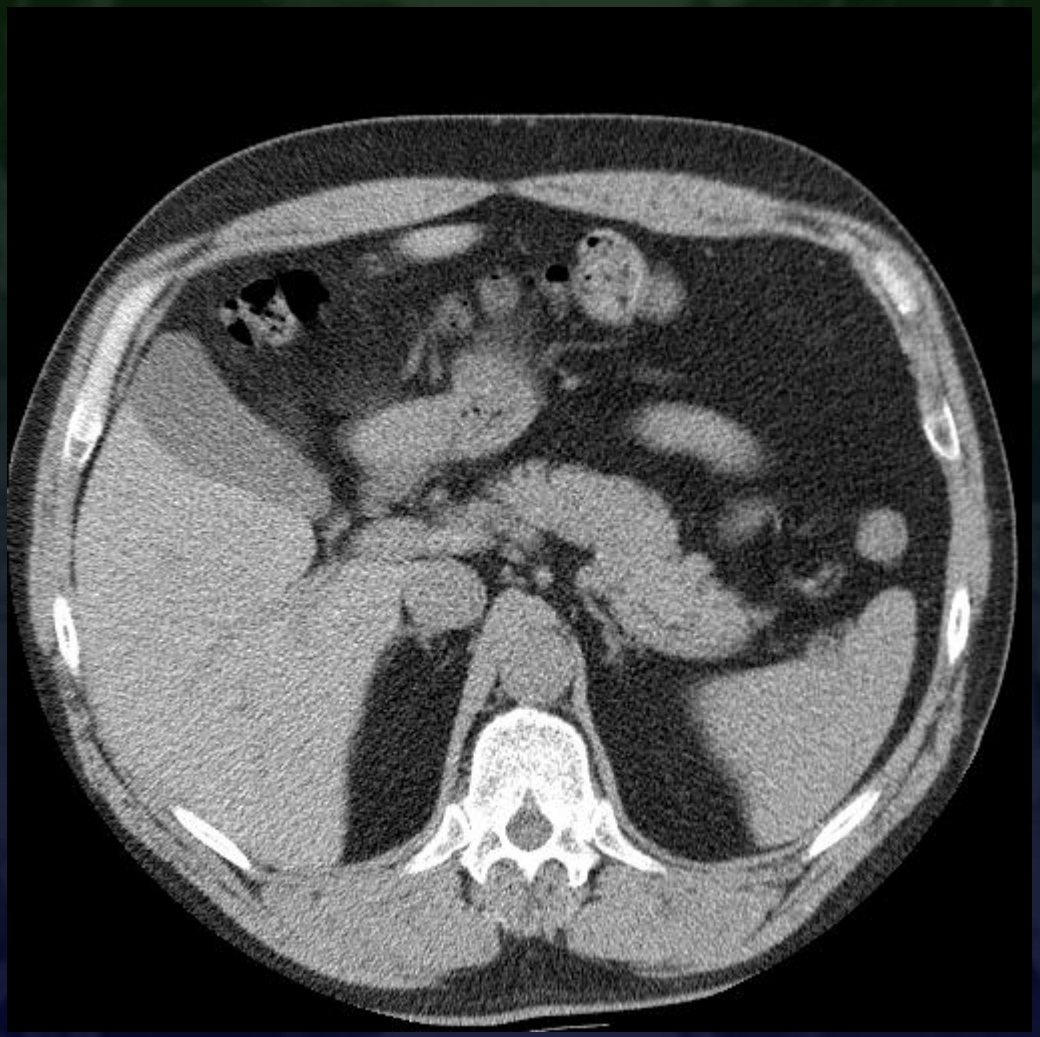

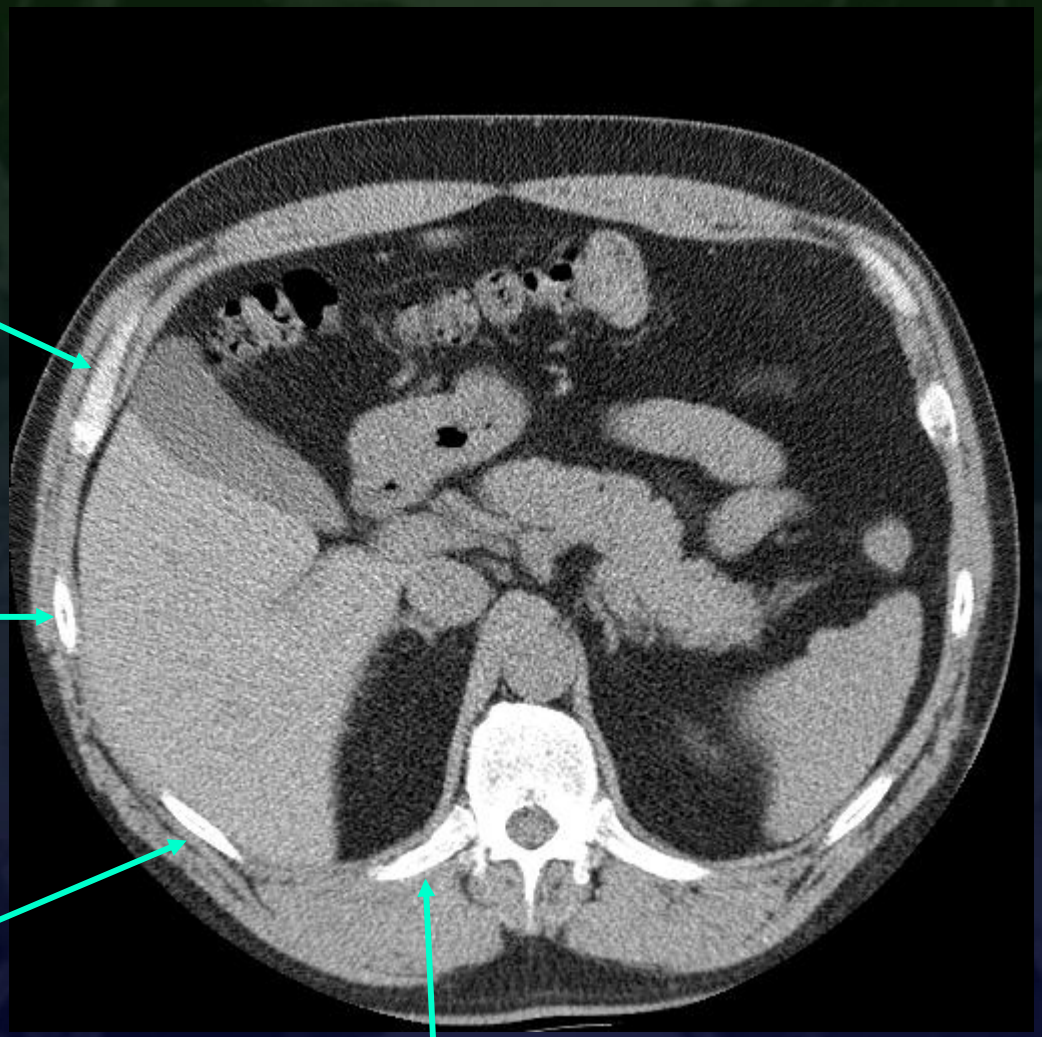
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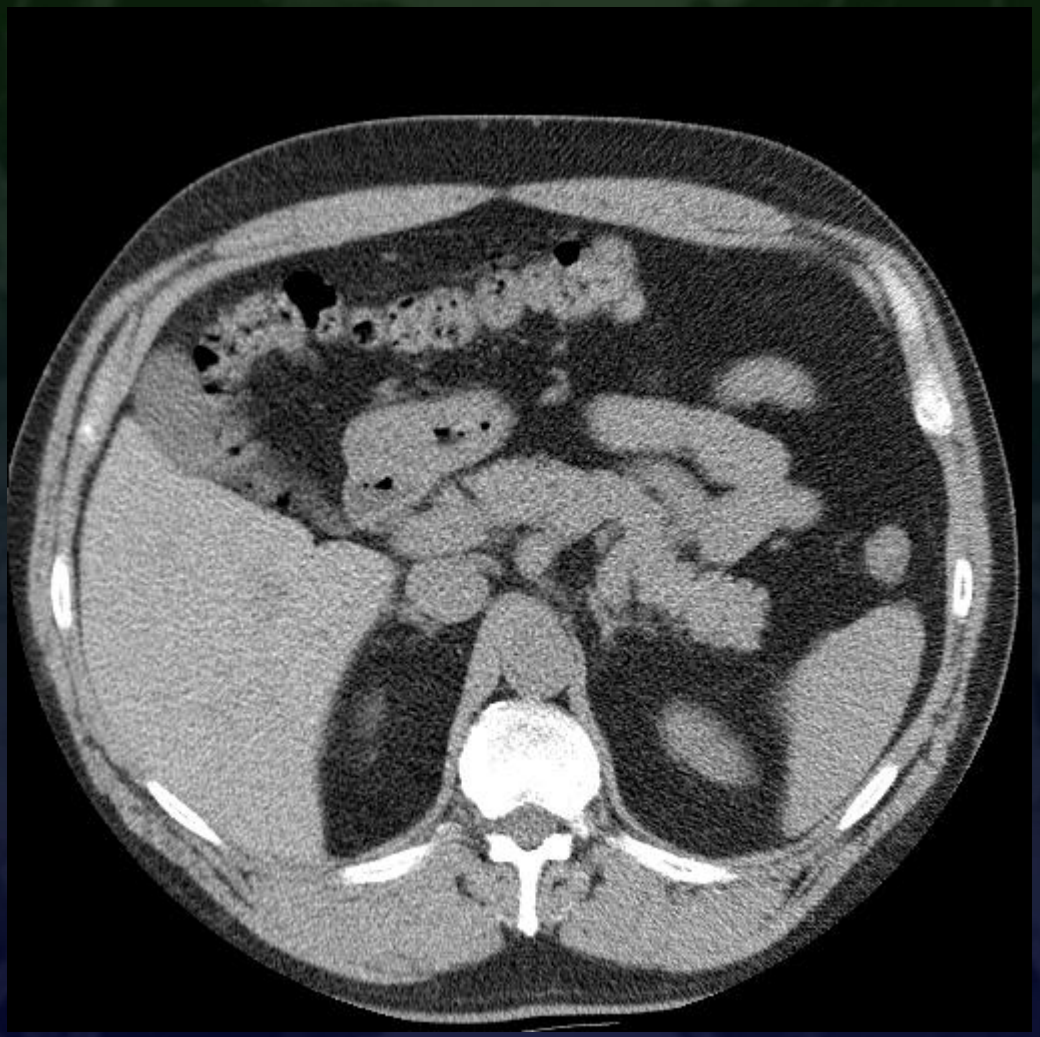

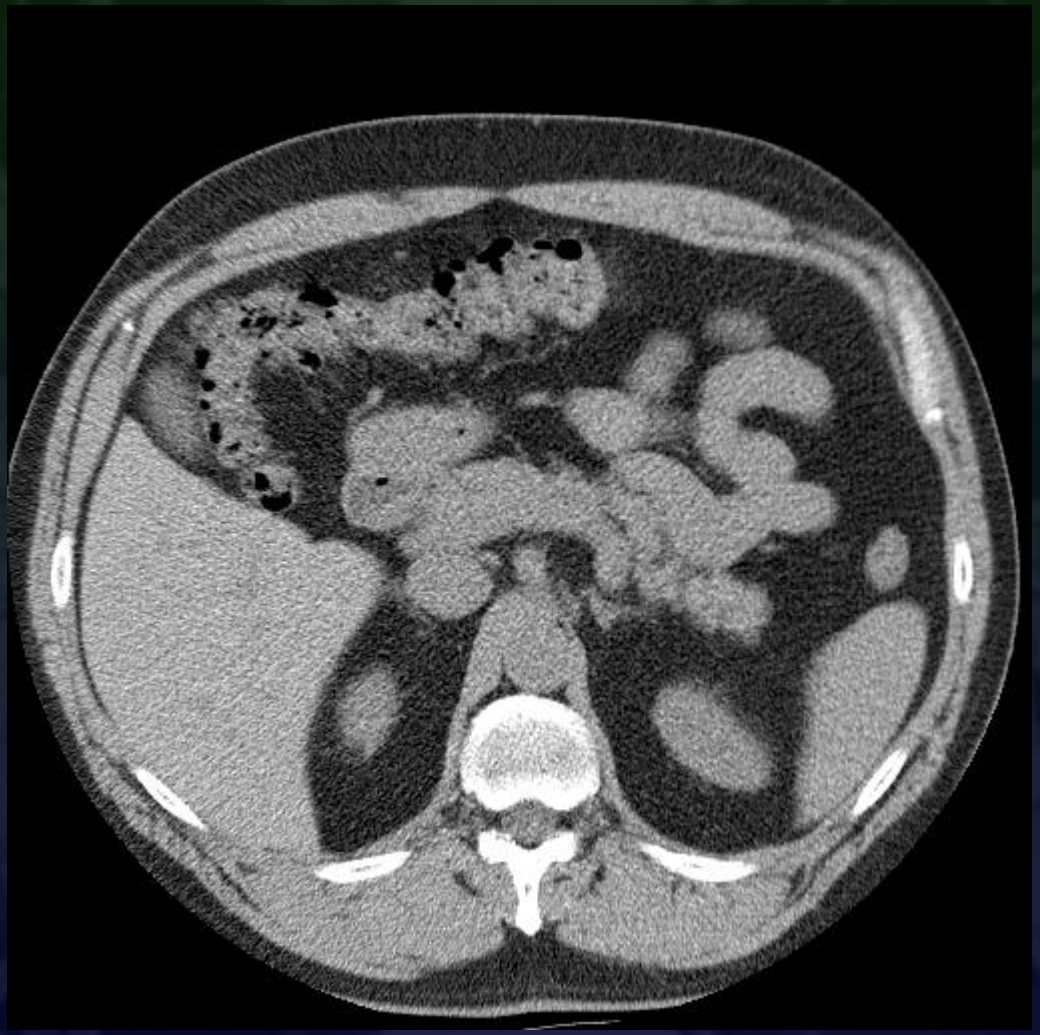

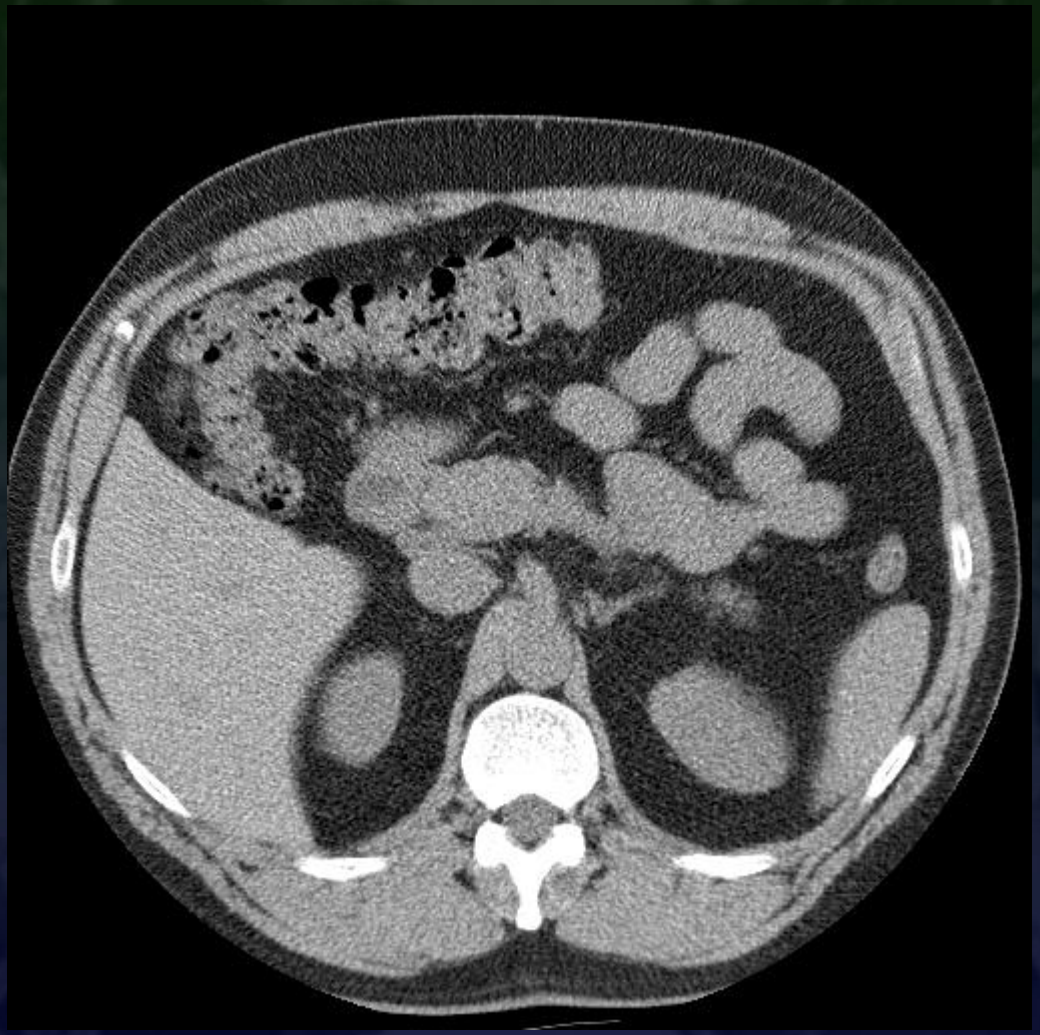

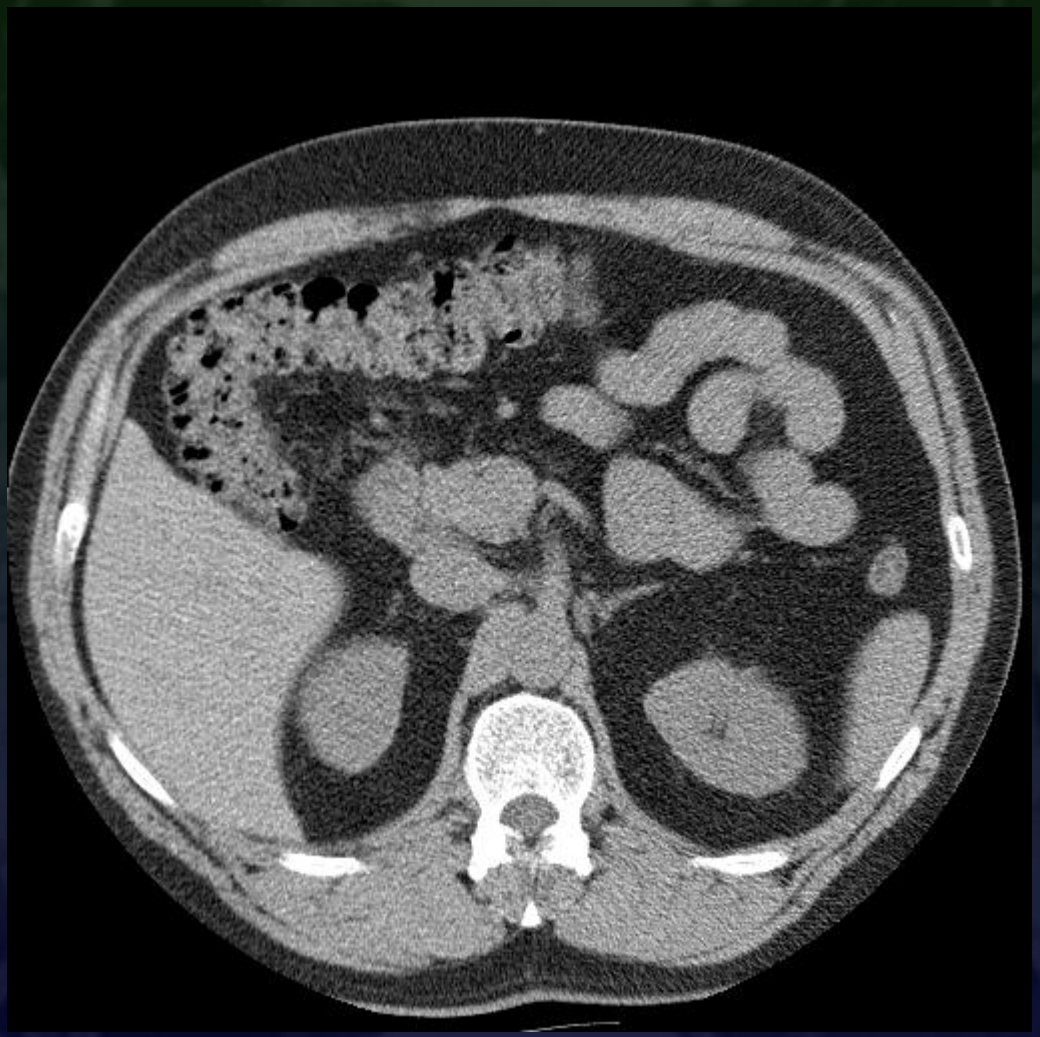

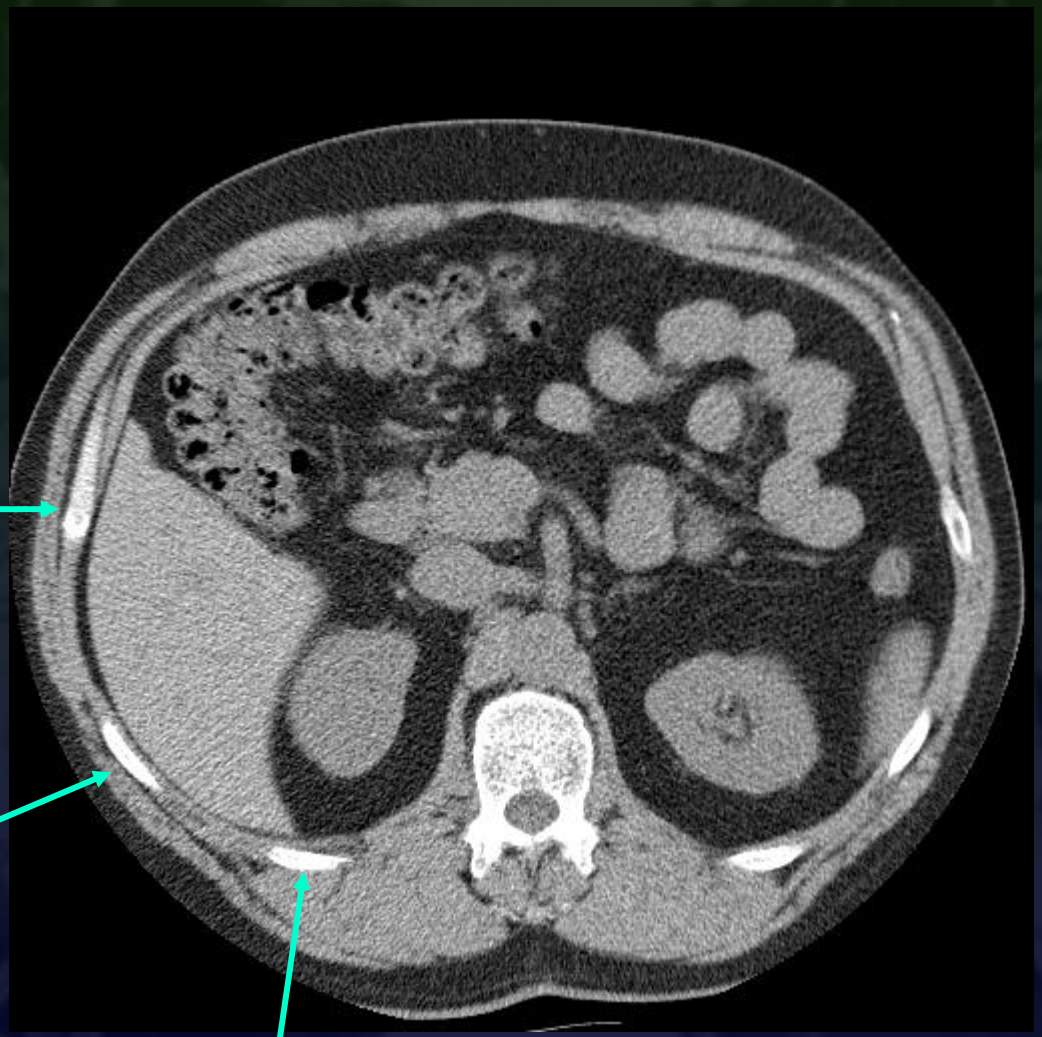
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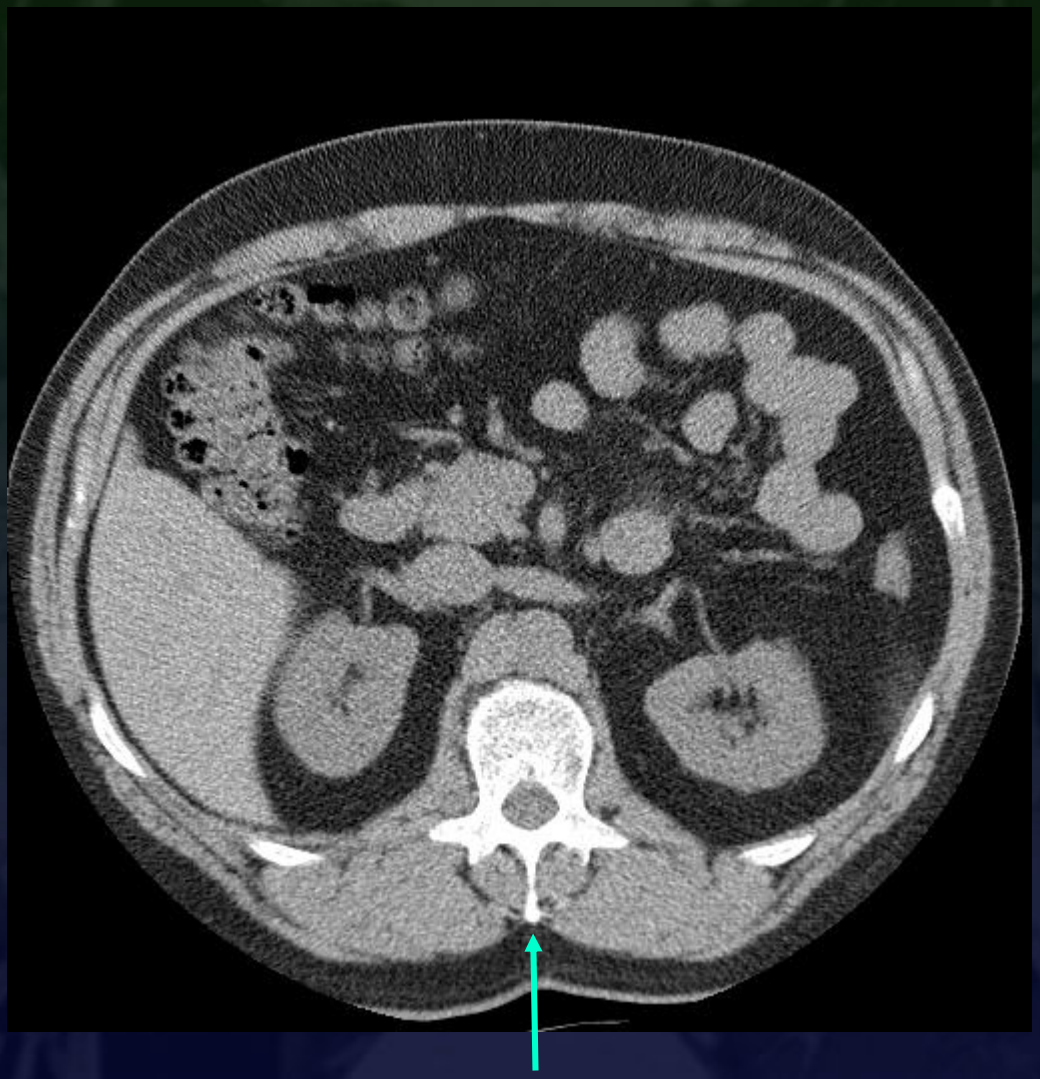

L1 Vertebral Body (No rib)

Summary

- Landmark anatomy!
  - veins, arteries
  - bronchial divisions, lung fissures
  - pulmonary circulation, cardiac chambers
  - lymph node groups – named according to location
- Left and right are not the same!
  - be careful not to inadvertently label normal structures as “lymphadenopathy”
  - bronchial and lung anatomy (right lung has 3 lobes)
  - bronchopulmonary segments (main branching can be seen on CT)
- Follow along multiple slices if unsure of a particular structure’s identity!

The End