Anterior Spinal Artery Syndrome as Complication of Bronchial/Intercostal Artery Embolization

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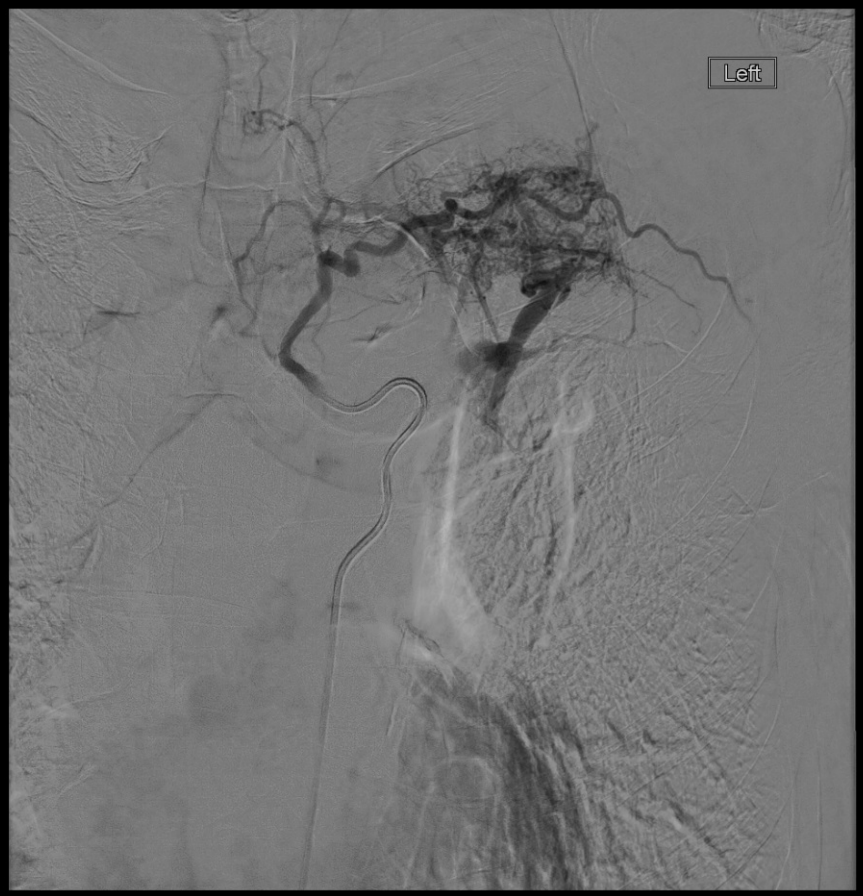
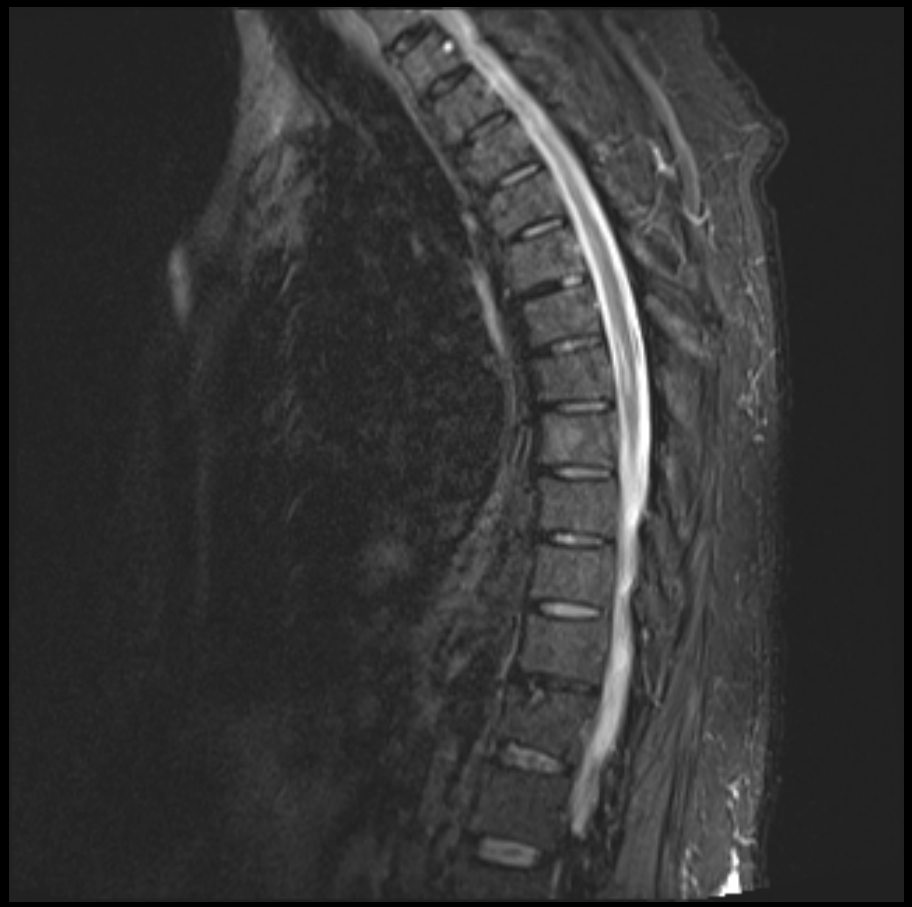
CAIR RFS VAC Feb 24, 2021





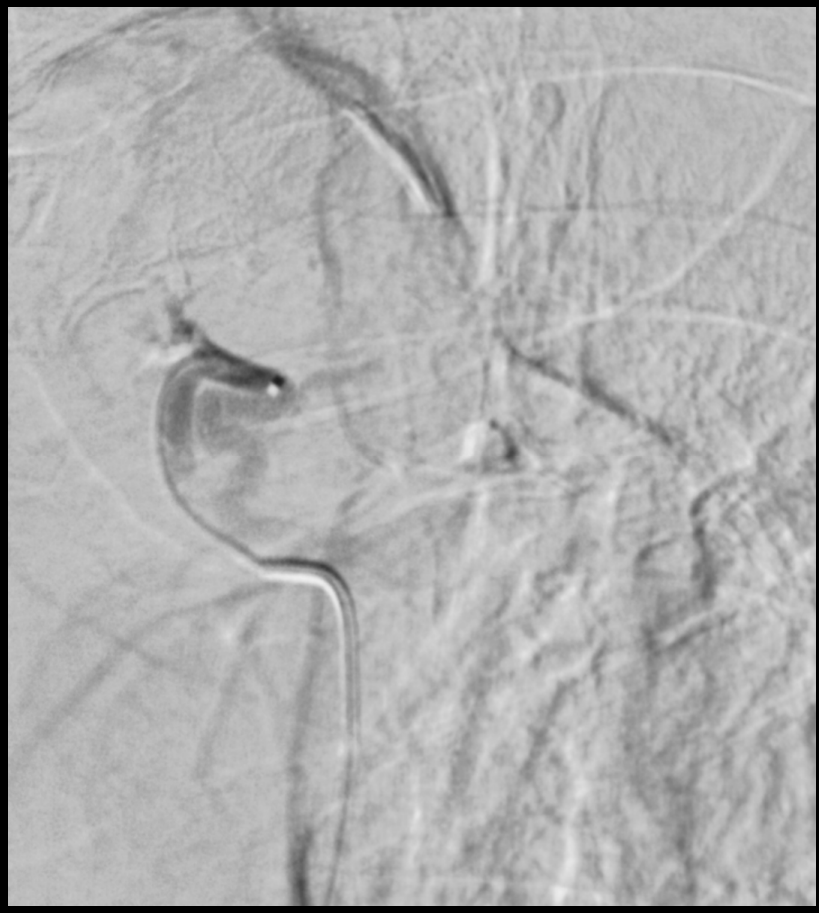
Profile: 65 M with previous pulmonary tuberculosis infection and associated bronchiectasis

PMH:

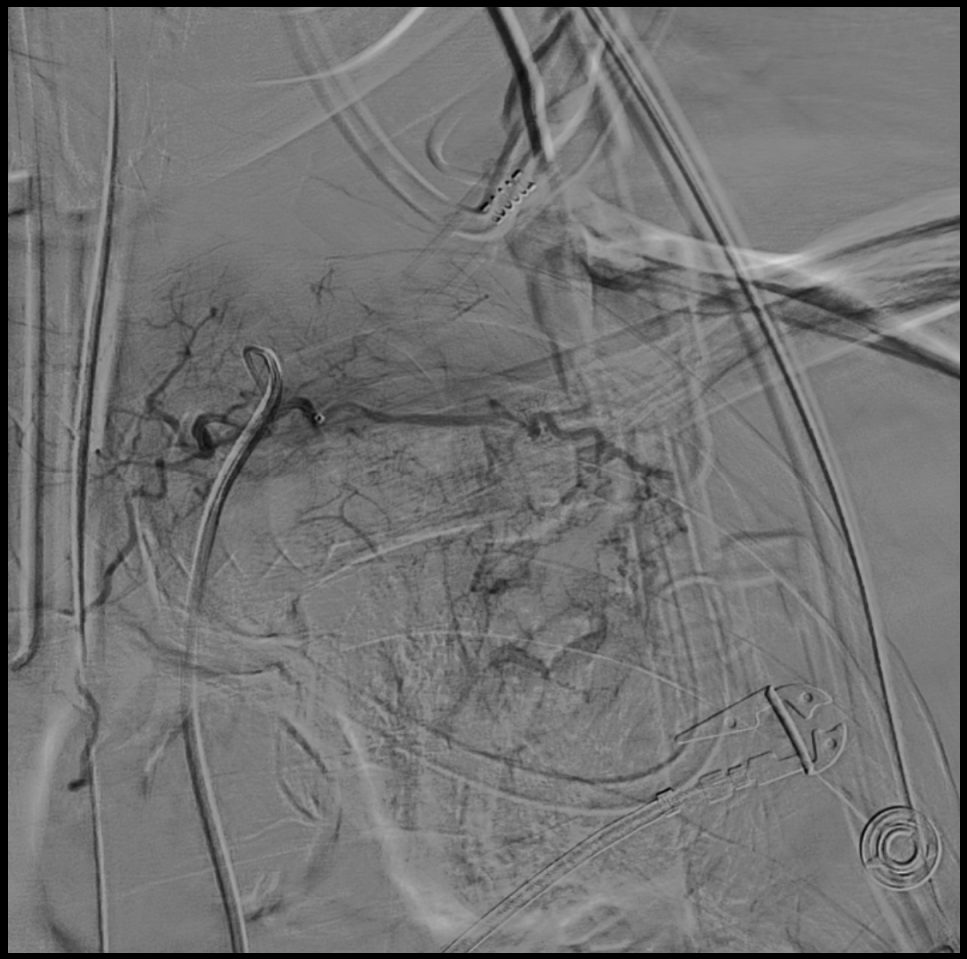
1. Recurrent hemoptysis treated with 2 prior embolizations – Left upper lobe bronchial artery and left 1st and 2nd intercostal arteries
2. CAD
3. Stage 3 Chronic Kidney Disease
4. Hypertension
5. Diabetes Mellitus

Presentation: Significant hemoptysis treated conservatively with broad spectrum antibiotics and tranexamic acid which did not resolve

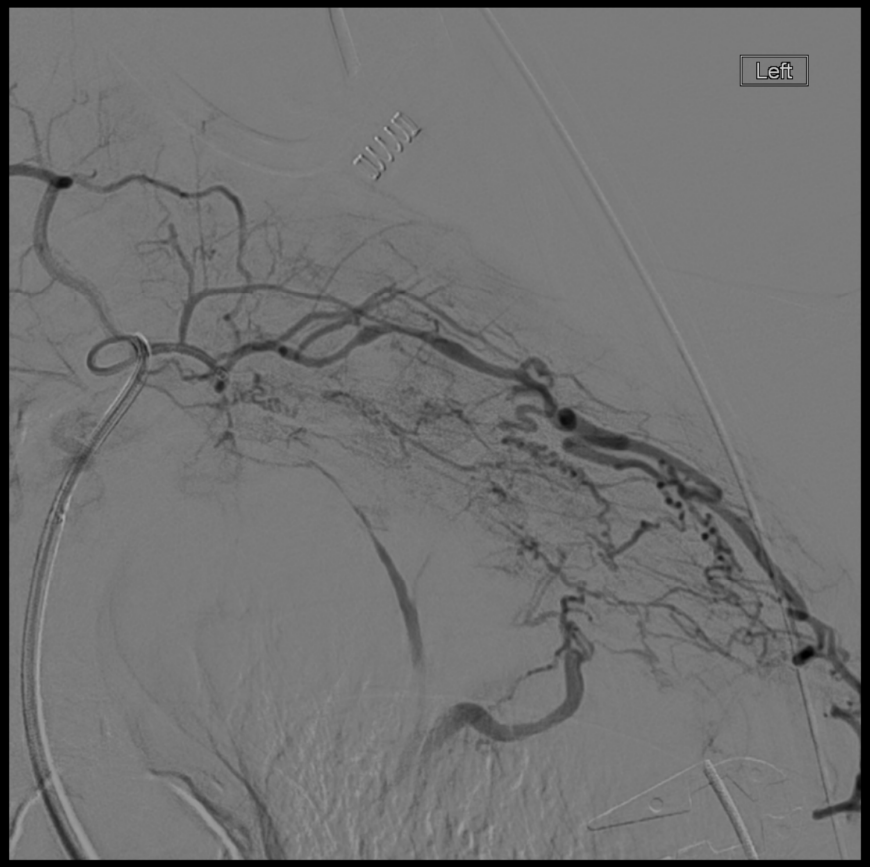
Setting the stage….

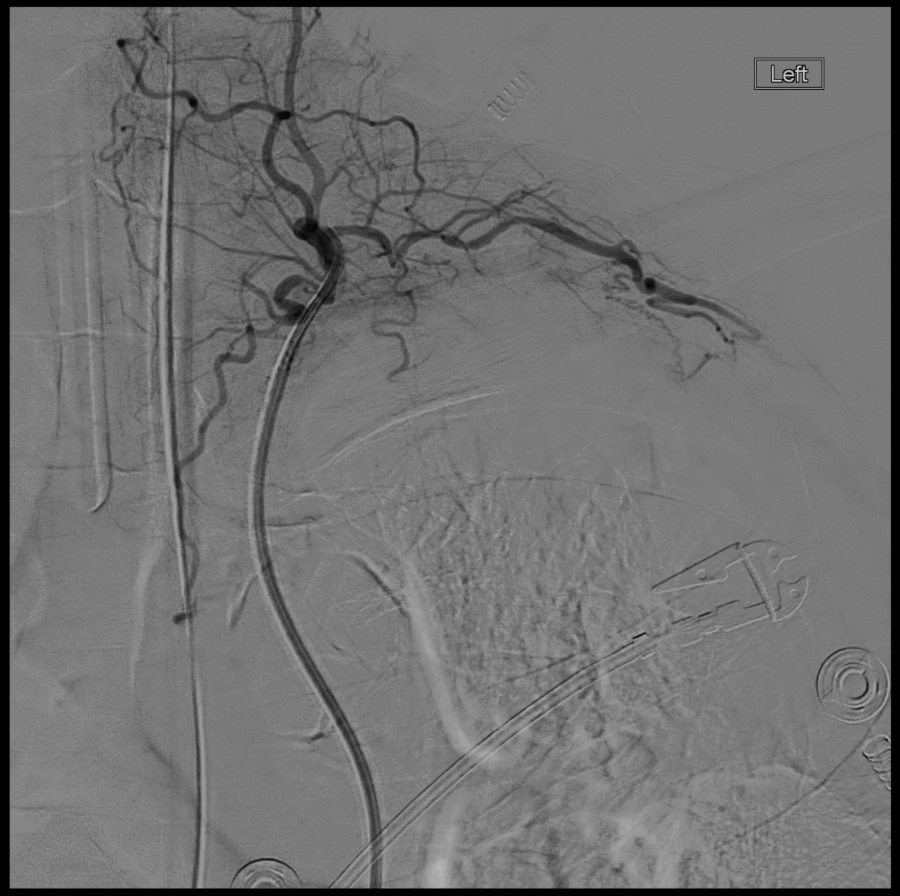


Prior left bronchial artery embolization with 500-700 embospheres 4 years prior, pre (left) and post (right) embolization.

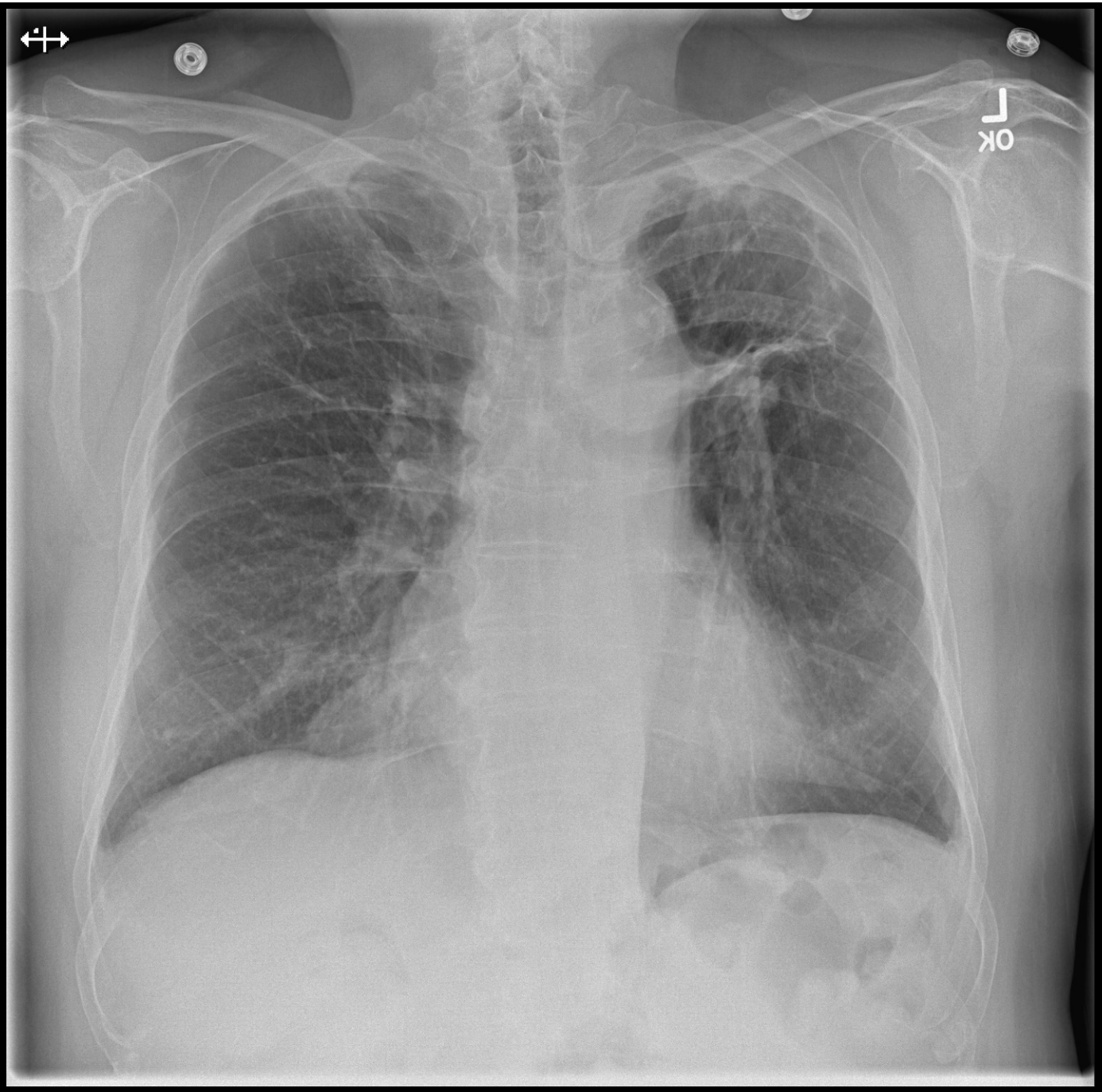


Subsequent procedure with embolization of the left second intercostal with 500-700 um PVA 4 years prior, pre (left) and post (right) embolization.

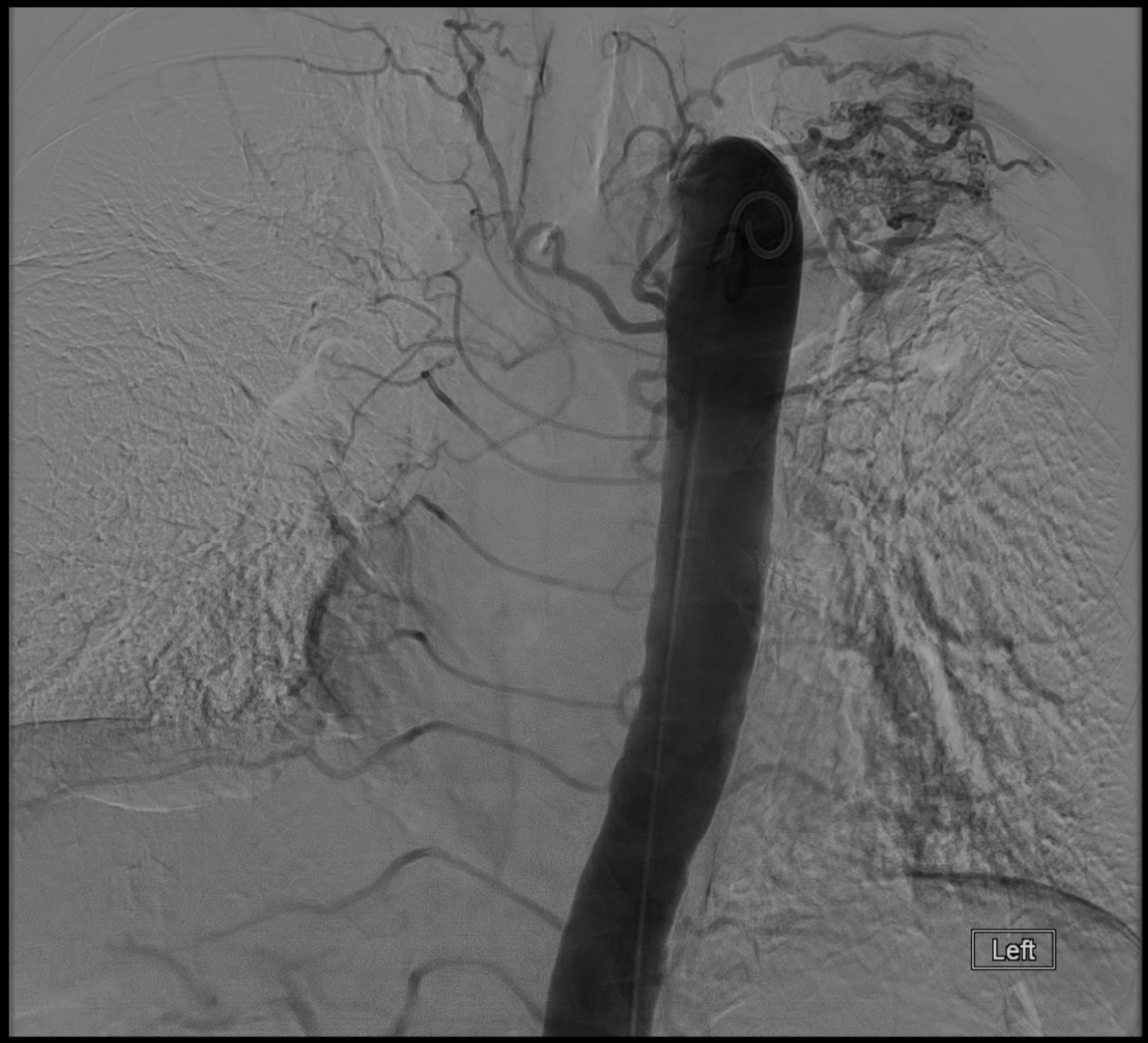




Subsequent embolization of the left first intercostal artery with 500-700 embospheres 4 years prior, pre (left) and post (right) embolization.

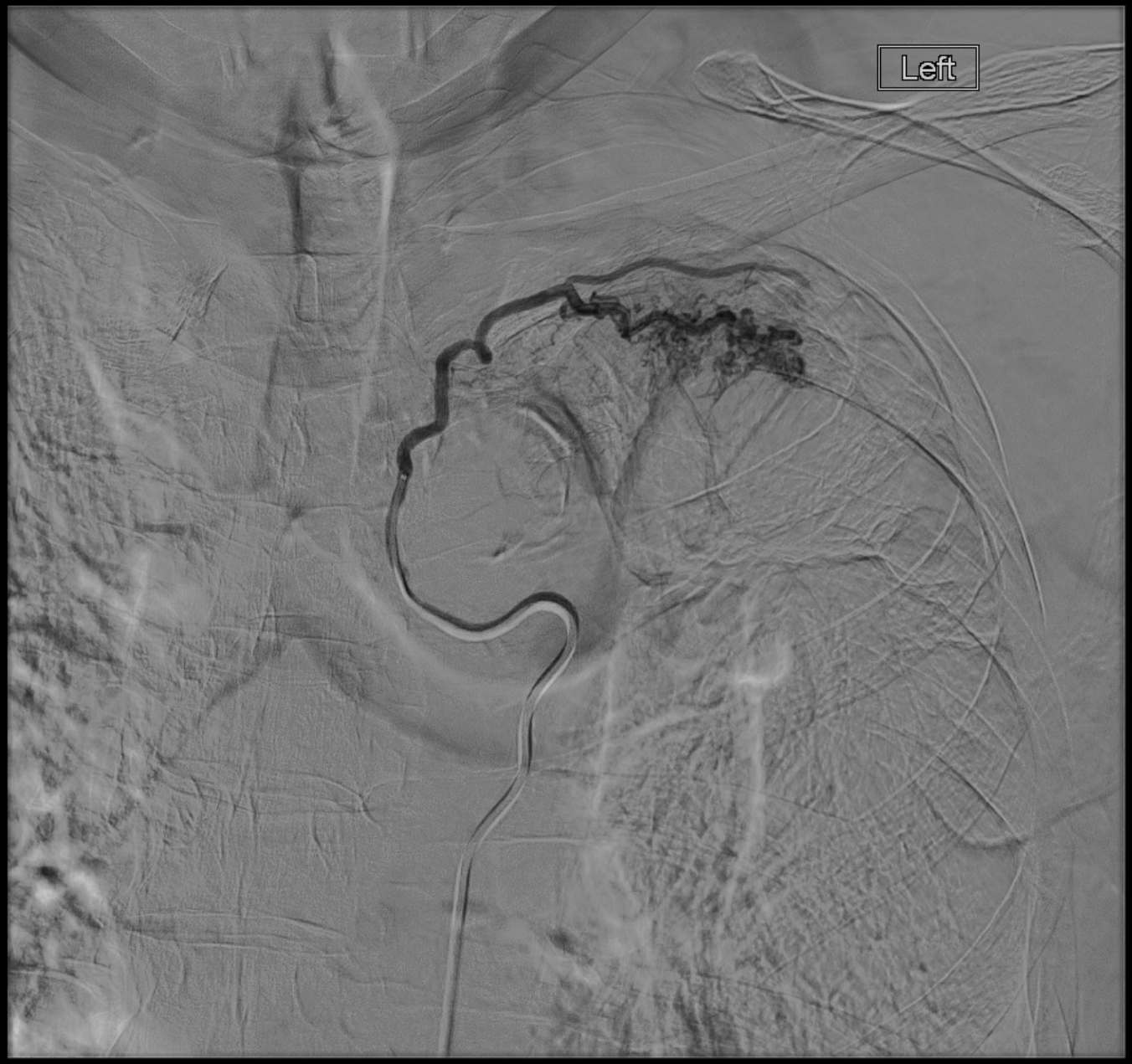


Chest radiograph from day prior to embolization demonstrating chronic bilateral apical scarring more pronounced on the left with associated volume loss and upward retraction of left hilum.



- Aortogram demonstrating left upper lobe (LUL) neovascularity supplied by intercostal collaterals and PA shunting

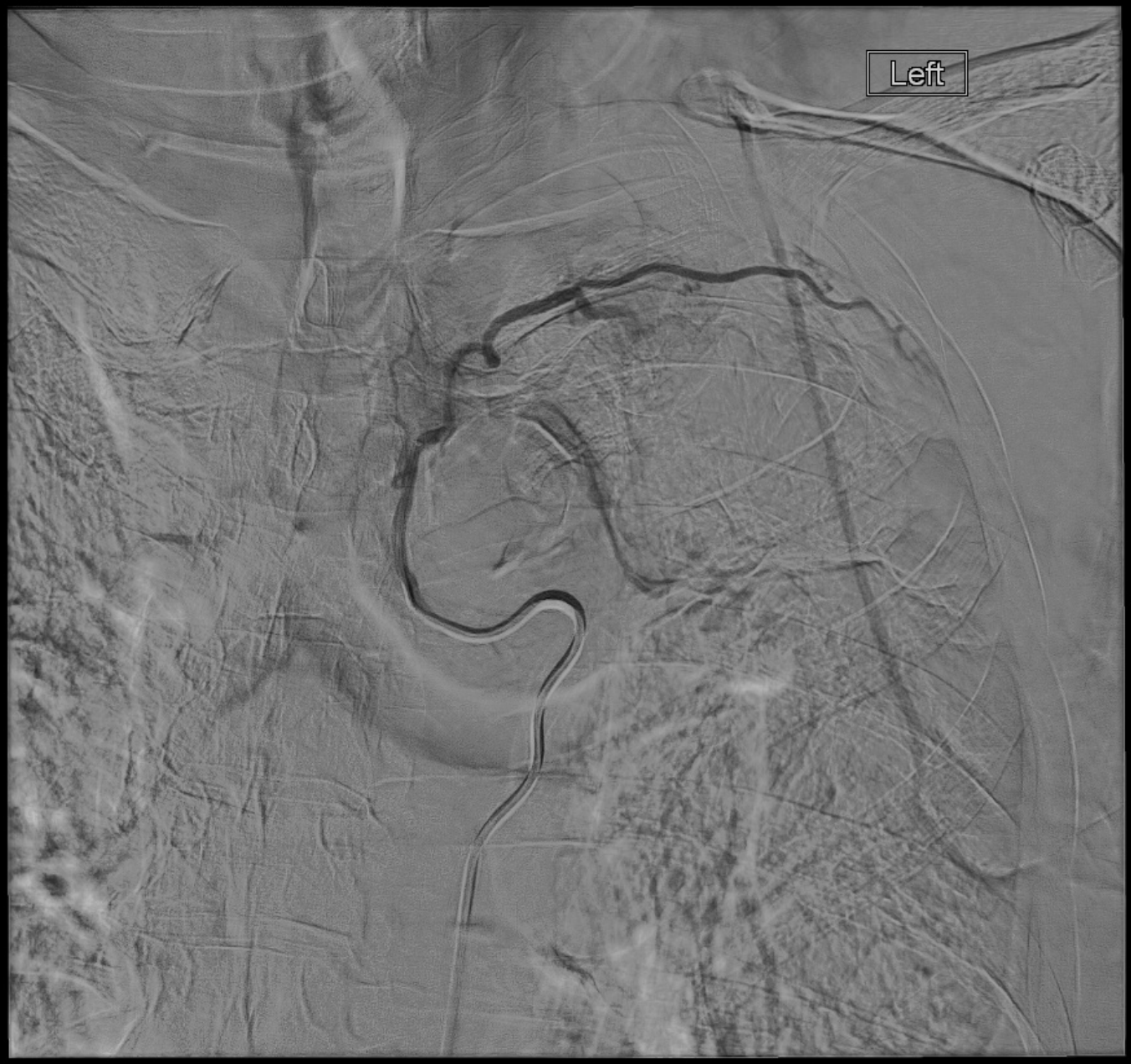
Mikaelsson (MIK) catheter selection of a left intercostal artery with angiogram demonstrating markedly abnormal neovascularity and PA shunting. Collateral supply to other intercostals may in part relate to recruitment/collateralization due to prior embolization



Selection of intercostal artery with Progreat microcatheter redemonstrating abnormal neovascularity and PA shunting

Given the large amount of shunting, a small amount of 700 -900 um particles were used which successfully resolved the PA shunting

Microcatheter selection of solitary left intercostal artery with subsequent embolization with 300-500 um particles



Angiogram post left intercostal artery embolization with resolution of abnormal neovascularity

Right intercostalbronchial artery trunk angiogram demonstrating abnormal neovascularity and right bronchial artery arising from right intercostobronchial trunk

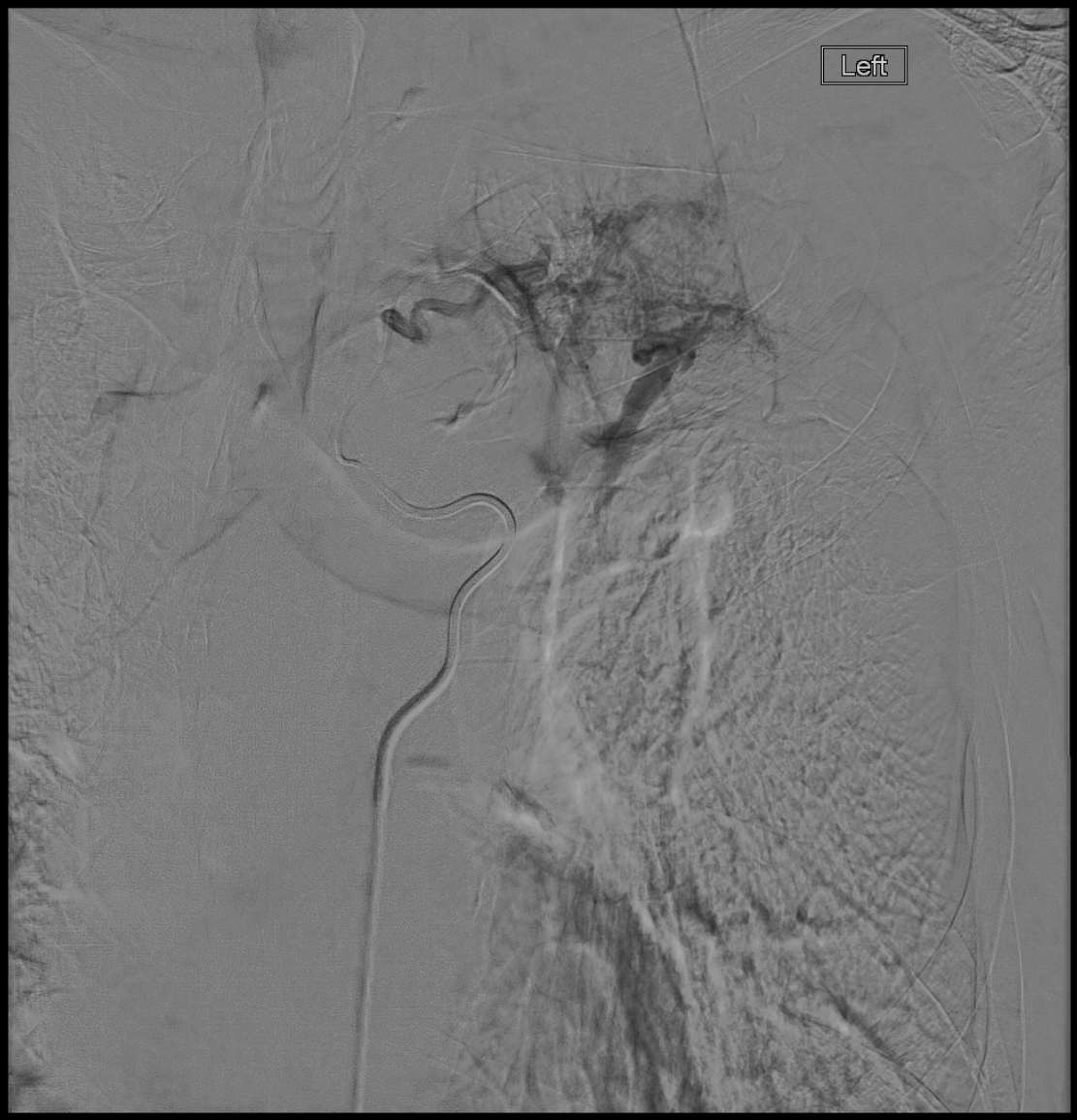
Microcatheter selection of distal right bronchial artery branch with angiograms pre (left) and post (right) embolization with 300-500 um particles.

Separate left intercostal artery angiogram with no associated abnormal neovascularity

Angiogram of additional left intercostal artery demonstrating abnormal neovascularity and PA shunting. Possible small spinal arteries demonstrated medially.

Microcatheter selection of left intercostal artery past possible spinal artery supply with angiograms of pre (left) and post (right) embolization using 700-900 um particles to treat PA shunting followed by 300-500 um particles. Post embolization image demonstrates resolution of PA shunting and embolization of abnormal neovascularity.

Repeat left intercostal angiogram of the initially treated bronchial artery demonstrating persistent abnormal neovascularity and shunting to pulmonary artery branch. Possible altered flow dynamics, likely relating to preceding embolization



Distal selection of left intercostal artery

Angiograms pre (left) and post (right) embolization using 700-900 um particles to treat PA shunting, followed by 300-500 um particles with resolution of PA shunting and embolization of abnormal neovascularity.

Outcome:

- Technically and clinically successful (resolution of hemoptysis)

- Next day, patient endorsed left leg weakness which resulted in Neurology consult with physical exam demonstrating 4/5 weakness in left lower extremity with decreased pain and temperature sensation up to the T5-6 dermatome on the right. Remainder of physical exam including reflexes and tone were normal.

Subtle linear STIR/T2 hyperintensity within anterior spinal cord located at T6-8.

Corresponding T2 hyperintensity at T6-8 levels of anterior spinal cord.

Subtle linear STIR/T2 hyperintensity within anterior spinal cord located at T6-8.

Corresponding T2 hyperintensity at T6-8 levels of anterior spinal cord.

… could represent cord edema/ischemic injury in this clinical setting

Clinical Course:

- Mild functional deficits
- Made good recovery with rehabilitative therapy

Discussion:

1) Variant/complex anatomy from systemic recruitment in setting of prior embolization (subclavian, internal mammary arteries)

2) Embolization may alter flow dynamics increasing risk

3) Role for CBCT – delineating spinal feeders

4) Temporary vs permanent agents
    1) Size (larger protective?)

5) Radiopaque particles vs suspended

Occluded superior left bronchial artery branch from prior embolization

Causes of Hemoptypsis

Table 1 Causes of hemoptysis

Pulmonary diseases
Tuberculosis
Aspergilloma
Pneumonia
Bronchiectasis
Lung malignancy
Chronic obstructive airways disease
Lung abscess
Cystic fibrosis
Sarcoidosis
Vasculitis: Behçet's disease, Wegener's granulomatosis
Cardiovascular diseases
Pulmonary artery arteriovenous malformation/aneurysm
Pulmonary embolism
Pulmonary hypertension
Bronchial artery aneurysm
Thoracic aortic aneurysm rupture/dissection
Aortobronchial fistula
Others
Coagulopathy
Iatrogenic: anticoagulation, Swan-Ganz catheters
Trauma

Developed World

Developing World

- Idiopathic/cryptogenic

Yoon et al Radiographics 2002
Chun et al CVIR 2010

Bronchial Artery Embolization

- First described in 1974 by Remy et al. for treatment of hemoptysis

- Why perform?
- Massive hemoptysis (> 300-600 mL/24 hr) has mortality rates of
  - 50-100% with conservative management
  - 40% with emergent surgical management

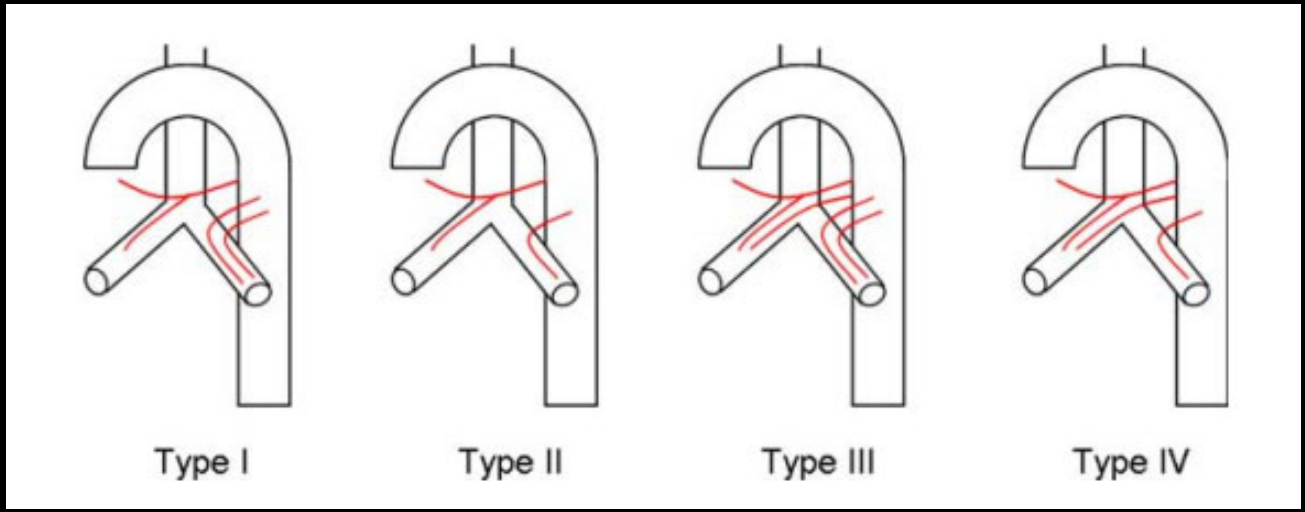
- Good technical and clinical outcomes
  - 81-100% technical success of being able to cannulate and embolize all visualized abnormal vessels
  - 70-99% immediate clinical success (complete cessation of hemoptysis)

- Low complication rate
  - 0-6.6% major complication rate
  - No complication and 1 major complications in recent retrospective reviews of 84 and 38 patients

Remy et al. Ann Radiol. 19
Chun et al. CVIR 2010
Panda et al. DIR 2017
Han et a. JVIR 2019
Martin et al. JVIR 2020

Bronchial Artery Anatomy (Orthotopic)

Typically arise from thoracic aorta between superior margin of T5 and inferior margin of T6



Four main types bronchial artery anatomy.

Types:

- I (40.6%): One right bronchial artery from right intercostobronchial trunk (ICBT), two left bronchial arteries.
- II (21.3%): One on the right from ICBT, one on the left.
- III (20.6%): Two on the right (one from ICBT and one bronchial artery), two on the left.
- IV (9.7%): Two on the right (one from ICBT and one bronchial artery), one on the left.

ICBT most consistent (80% of cases). Common origin of bilateral bronchial arteries can be seen ~45%

Chun et al CVIR 2010
Adapted from Cauldwell et al. Surg Gynecol Obstet 1948
Yoon et al. Radiographics 2002
Sidhu et al Semin Intervent Radiol 2008

Bronchial Artery Anatomy (Ectopic)

- Arise outside of T5-T6 (16.7-30%)
- Can arise from aortic arch (most commonly), brachiocephalic, subclavian, axillary, internal mammary, inferior phrenic arteries as well as thyro-/costocervical trunks, abdominal aorta, celiac and left gastric arteries
- Follow course of bronchi

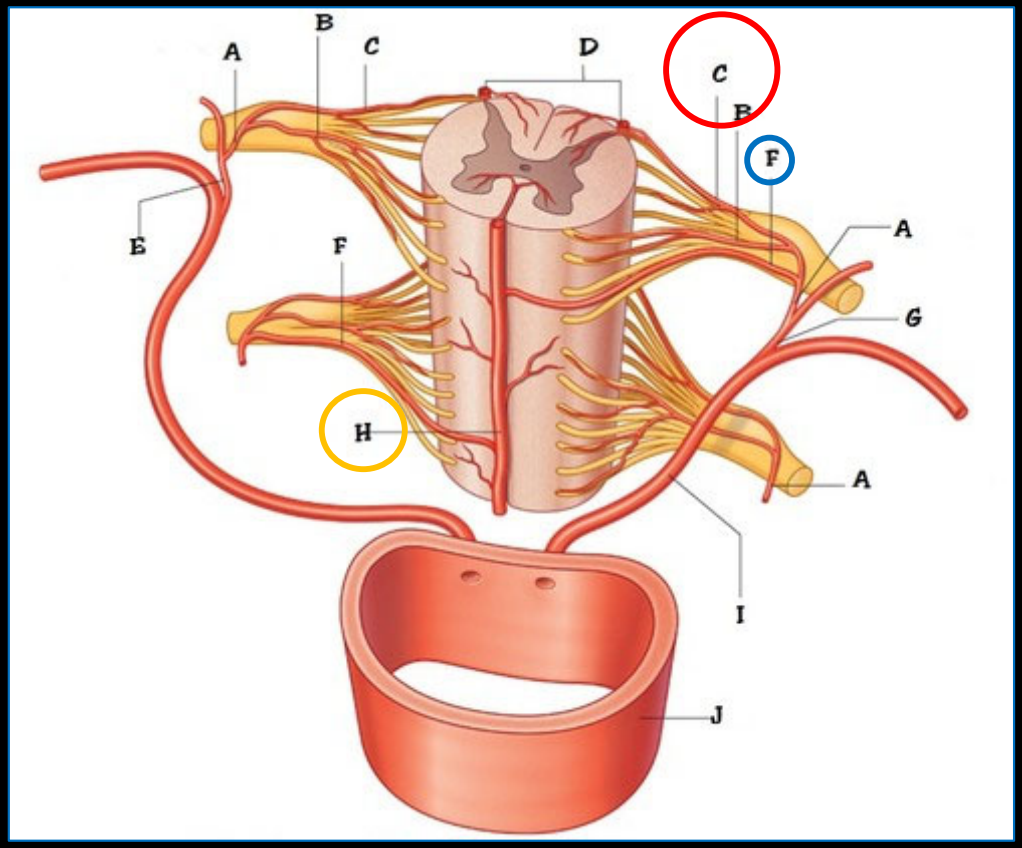
Aberrant Right Bronchial Artery arising from right internal mammary artery

Chun et al CVIR 2010
Yoon et al. Radiographics 2002

Non-Bronchial Systemic Arteries

- Intercostal arteries, branches of subclavian/axillary arteries, internal mammary and inferior phrenic arteries
- Enter the lung through pleura
- Do not follow the course of bronchi
- Commonly responsible for ongoing/recurrent hemoptysis despite successful BAE
- Many authors encourage an active search for these during initial angiography
- CT useful for predicting their presence
  - Pleural thickening >3mm
  - Enlarged vessels within hypertrophic extra-pleural fat

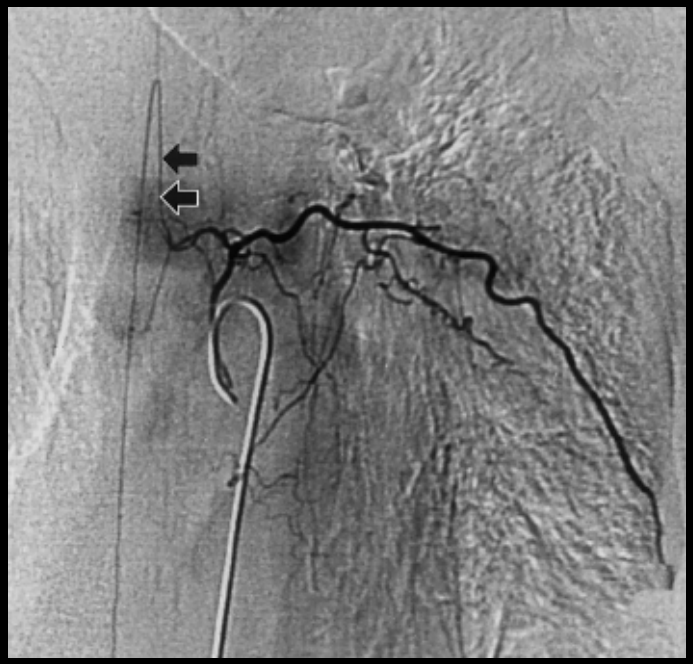
Spinal Arteries



A - segmental spinal artery
B - anterior radicular artery
C - posterior radicular artery
D - posterior spinal artery
E - posterior branch of right posterior intercostal
F - segmental medullary artery
G - posterior branch of left posterior intercostal
H - anterior spinal artery
I - posterior intercostal artery
J - aorta

Spinal Arteries

- Two types
  - Dorsal and Ventral Radicular Arteries which arise from segmental spinal arteries (supply nerve roots)
  - *± 8 segmental medullary arteries reinforce* anterior spinal artery (major source of spinal cord perfusion); characteristic "hairpin" configuration
  - In thoracic region, anterior spinal artery usually supplied by single anterior medullary branch however
    - *Artery of Adamkiewicz* (largest seg. medullary art) supplies the lumbar enlargement
      - *Arises btw T9 and T12 in 75% of cases*, but can arise anywhere btw T5 and L4
      - *Can arise from a BA in up to 5-10% of cases, mostly from the right ICBT*



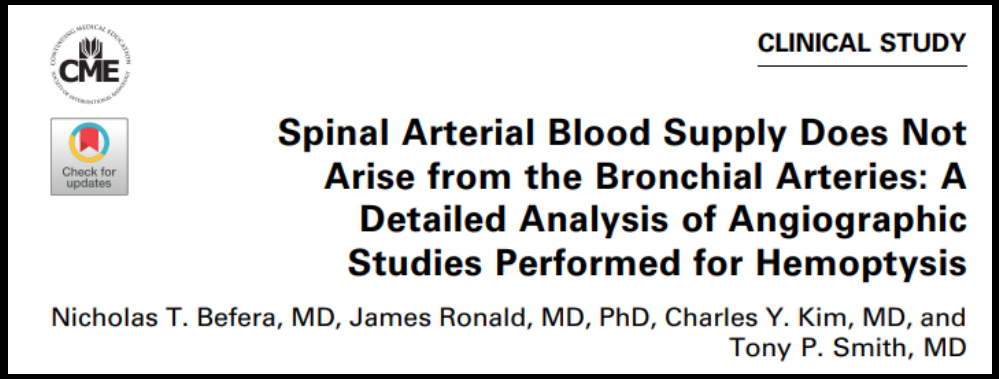
Left seventh intercostal angiogram showing an anterior medullary artery with typical hairpin configuration

Chun et al CVIR 2010
Yoon et al. Radiographics 2002
Sidhu et al. Semin Intervent Radiol 2008
Sopko et al. Semin Intervent Radiol 2011

Spinal Cord Ischemia

- Spinal cord ischemia most disastrous complication of BAE
- Prevalence
  - 1.4-6.5% (Yoon et al. 2002, Chun et a. 2010)
  - 0.6-4.4% (Panda et al. 2017)
- Traditionally, visualization of radicular arteries on bronchial or intercostal angiograms is not absolute contraindication as not felt to cause spinal cord ischemia (Yoon et al. 2002), but if anterior medullary artery is visualized at angiography, embolization show not be performed
  - First case published suspected to be result of ionic contrast material[8]
- Has been reported even when spinal arteries not visualized, potentially due to reflux (ensure distal)

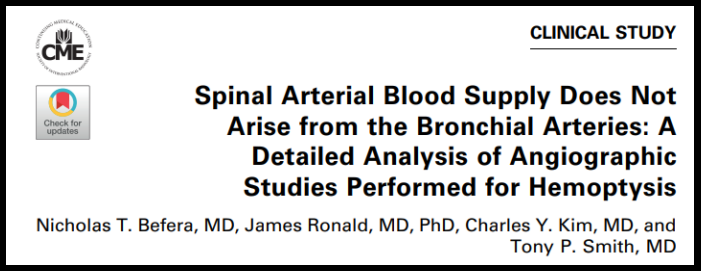
Recent work suggests spinal artery supply does not arise from bronchial artery supply but can originate from intercostal portion of ICBT artery


CLINICAL STUDY

Spinal Arterial Blood Supply Does Not Arise from the Bronchial Arteries: A Detailed Analysis of Angiographic Studies Performed for Hemoptysis

Nicholas T. Befera, MD, James Ronald, MD, PhD, Charles Y. Kim, MD, and Tony P. Smith, MD

Spinal Ischemia post BAE



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- 180 patients
- No spinal cord supply from any bronchial artery (308 arteries)
  - Including bronchial component of intercostal bronchial artery (118)
- Conventional spinal artery supply from intercostal arteries in 23 patients with spinal artery supply arising from intercostal portion of ICBT in 6 patients
- 5 right ICBT with spinal supply as well an intercostal artery were treated with superselective embolization (beyond spinal artery)

- However, neurologic complications have been reported even when spinal artery supply was not visualized suggesting need to embolize as distally as possible
- Particles > 350 um thought to be protective

Befera et al. JVIR 2019
Sidhu et al Semin Intervent Radiol 2008

Other cases…

Anterior Spinal Cord Infarction following Bronchial Artery Embolization

Anthony C. Brown, M.D.[1] Charles E. Ray, M.D., Ph.D.[1]

- *Right bronchial artery embolization resulting in T1-T5 cord edema*

Anterior spinal cord infarction as a complication of bronchial artery embolization in the management of recurrent hemoptysis

Ramandeep Singh, Siddharth Prakash[1], Paramdeep Singh, Rupinderjeet Kaur[2], Rubal Rai[3]

- *Right bronchial artery embolization resulting in T2-T5 cord edema. No anterior spinal artery branches opacified during procedure*

ANTERIOR SPINAL CORD INFARCTION COMPLICATING BRONCHIAL ARTERY EMBOLIZATION IN A PATIENT WITH MASSIVE HEMOPTYSIS

SHAILESH BALASUBRAMANIAN MD* CLEVELAND CLINIC

GURAMRINDER THIND AND SUDHIR KRISHNAN

- *Two left lobe branches and one right lobe branch, subsequently developed complete paraplegia. MR – abnormal T2 signal T1-6*

E-068 SPINAL CORD INFARCTION AFTER BRONCHIAL ARTERY EMBOLISATION

[1]A Jammoul, [2]M Hussain. [1]*Adult Neurology, Cleveland Clinic Foundation, Cleveland, OH;* [2]*Vascular Neurology, Cleveland Clinic Foundation, Cleveland, OH*

Bronchial Artery Embolization for the Management of Hemoptysis in Oncology Patients: Utility and Prognostic Factors

Gin R. Wang, MD[a], Joe E. Ensor, PhD[b], Sanjay Gupta, MD[a], Marshall E. Hicks, MD[a], Alda L. Tam, MD[a,*]

- *T3 and T4 intercostal arteries embolized using 100-300 um embospheres ultimately resulting in T4 level infarction*

Annals of Indian Academy of Neurology
Official Journal of Indian Academy of Neurology
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Ann Indian Acad Neurol. 2016 Jan-Mar; 19(1): 156–157. PMCID: PMC4782540
doi: 10.4103/0972-2327.175494 PMID: 27011655

Spinal cord infarction after bronchial artery embolization

Boby Varkey Maramattom, BP Krishna Prasad,[1] Sandeep Padmanabhan, and Jacob Baby[2]

- *Left bronchial artery and left T10 intercostal artery embolization with subsequent T5-6 signal abnormality. No spinal arterial supply visualized.*

Spinal Cord Infarction and Stroke After Bronchial Artery Embolization for Massive Hemoptysis: A Double Whammy

Muhammed I. Shaukat , , Mohammed Moizuddin , Jake Krieg ,

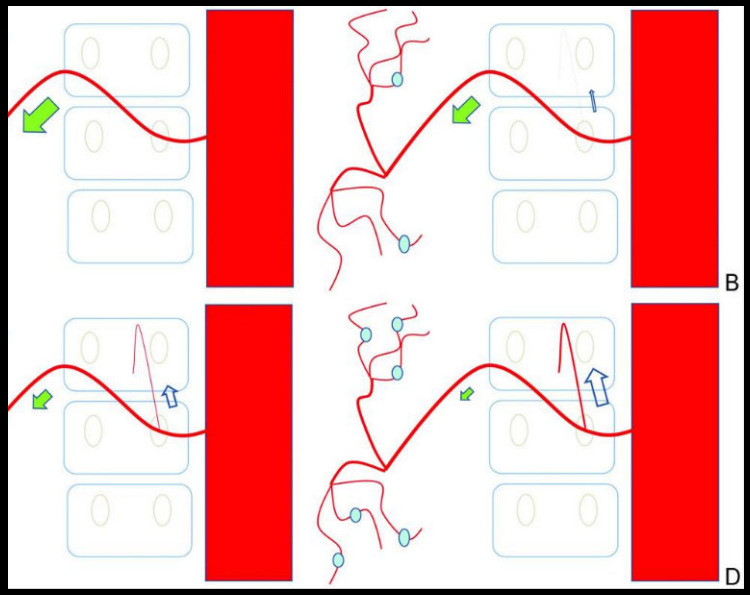
- *Left lower lobe BAE followed by posterior circulation T2/FLAIR hyperintensities and abnormal signal at T1-3*

Take Home Points:

1) BAE has high rates of technical and clinical success in treating massive hemoptysis

2) Spinal cord ischemia, the most feared complication of BAE has a prevalence of 1.4-6.5%

3) Cases of spinal cord ischemia have occurred when spinal arteries were not visualized, suggesting angiographically occult branches may only become visible after flow dynamics are altered



Brown et al. Semin Intervent Radiol 2012

Closing Discussion

1) Personal experience

2) Role for CBCT – delineating spinal feeders

3) Temporary vs permanent agents
   a) Size (larger protective?)

4) Radiopaque particles vs suspended – improved visualization of embolization

5) Role for general anesthesia and apnea? – improved visualization of spinal artery

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