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# DISCLOSURES

- None

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Handouts:

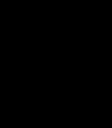
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Folder: SCCT 2015

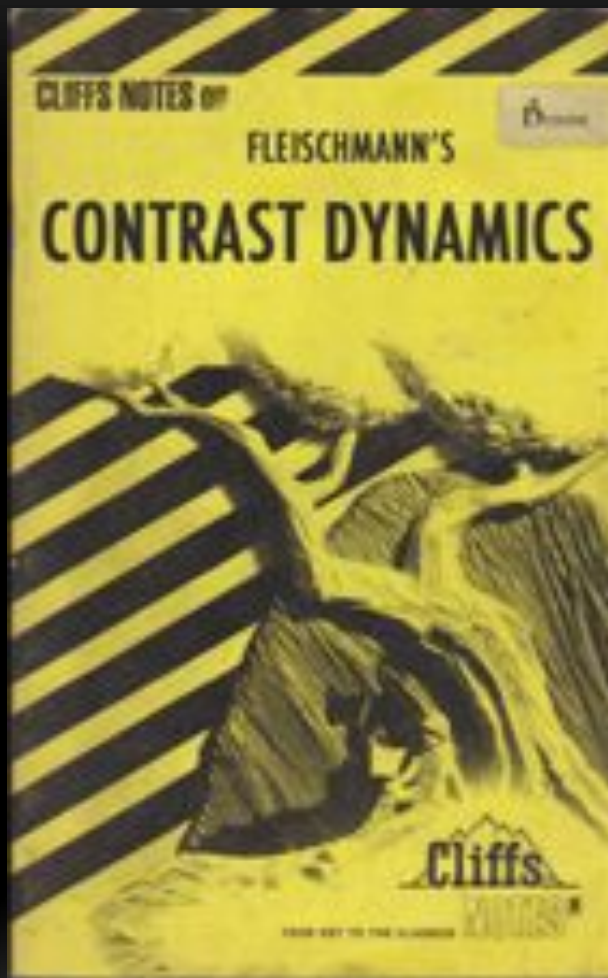


# OUTLINE

- Contrast Medium Considerations for Aortic / Pulmonary CTA
- Scan Acquisition Considerations
- Pathology:
- Pulmonary:
  - Acute and Chronic PE
- Aorta:
  - Acute Aortic Syndromes



# CONTRAST MEDIUM DYNAMICS FOR CTA



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# EARLY CONTRAST DYNAMICS

## KEY RULES FOR CTA

- 1 Arterial enhancement is proportional to Iodine administration rates

(inverse to CO and Body Weight)

- 2 Arterial enhancement increases ("cumulative") with longer injection duration
- 3 Adjust inj. rate and CM volume ( $\pm 20\%$ ) for pts.  $\leq 60\text{kg}$  and  $\geq 90\text{kg}$





# EXAMPLE: 64-SLICE CTPA

(BOLUS TRACKING, SCAN TIME ~ 5 SEC)

Pt Weight (kg)	Total CM (mL)	Flow Rate (mL/s)
<65	70	4.5
65-85	80	5.0
85-100	90	5.5
>100	100	6.0

16 sec Inj. Duration



# WEIGHT-BASED CM DOSING – AORTA

- Scan times more variable (1-15 sec) depending on choice of scan and type of ECG synchronization
- Use of **fixed scan-times** improves consistency
- **Biphasic CM injection** can decrease total CM dose, maintain adequate enhancement



# EXAMPLE: THORACIC AORTA

Weight (kg)	Injection 1	Injection 2
< 55	20 mL @ 4.0 mL/s	(scan time - 5) x 3.2 mL/s
55-65	23 mL @ 4.5 mL/s	(scan time - 5) x 3.6
65-85	25 mL @ 5.0 mL/s	(scan time - 5) x 4.0
85-95	28 mL @ 5.5 mL/s	(scan time - 5) x 4.4
>95	30 mL @ 6.0 mL/s	(scan time - 5) x 4.8

Saline chaser: 30-40 mL at CM injection flow rate

Bolus track ascending aorta (or other region of maximal interest)

Minimal diagnostic delay (5 sec)

# SCAN ACQUISITION - PULMONARY

- Non-gated acquisition (helical, Flash)
- Short scan times
- Bolus Tracking (or timing bolus)
- Contrast Medium Optimization needed
- Pitfall Prevention!
  - Valsalva
  - Extravasation
  - Image noise



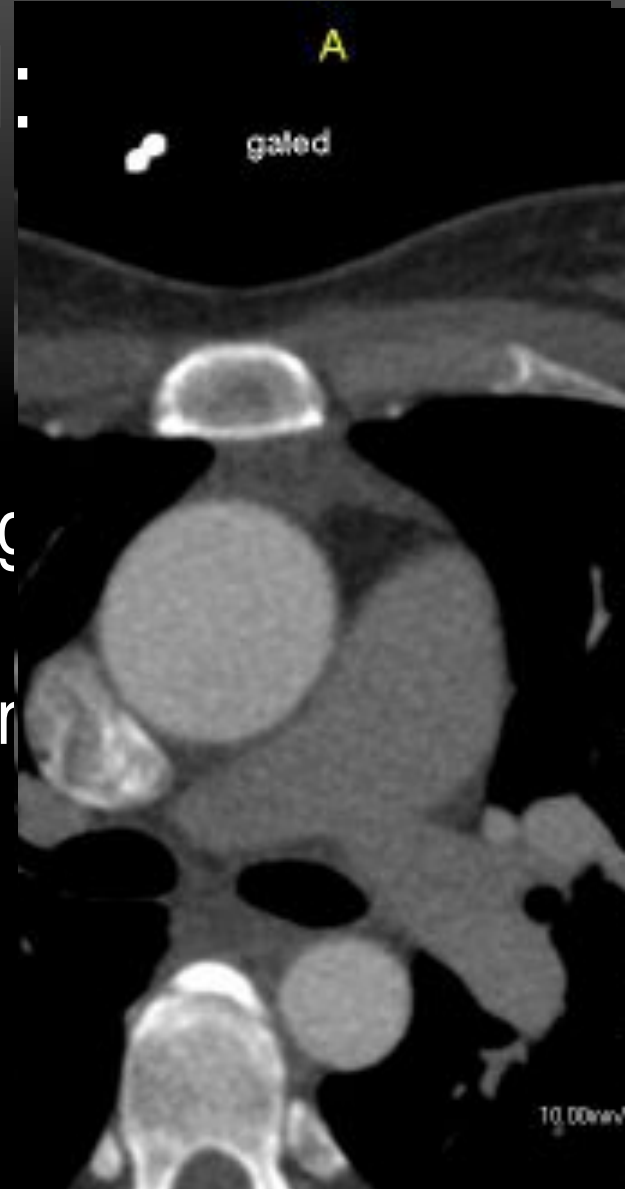
# SCAN ACQUISITION: AORTA

- Non-contrast series necessary (at least in acute)
- Coverage of potential extent of dissection
  - CTA C-A-P
- ECG synchronization
  - Needed for root / ascending / dynamic flap obstruction
- No NTG, B-blockers



# ECG SYNCHRONIZATION: AORTA

- ECG synchronization often needed:
  - assessment of pathology involving ascending thoracic aorta
  - DSX flap: obstruction/complication
- Choice of method:
  - Prospective triggering
  - Retrospective gating
  - High speed helical (Flash)





A grayscale axial CT scan of the chest, showing the lungs, heart, and major blood vessels. The image is centered on the pulmonary arteries. A large, dark, filling defect is visible in the right pulmonary artery, indicating a pulmonary embolism. The surrounding lung parenchyma and mediastinal structures are also visible. A scale bar at the bottom indicates 10.0 cm.

# PULMONARY EMBOLISM

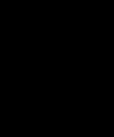
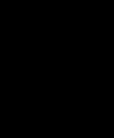


# ACUTE PULMONARY EMBOLISM

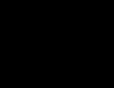
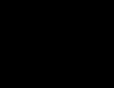
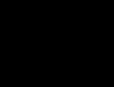


# GOALS IN ACUTE PE IMAGING

- Who should get CTPA?
- Who should NOT get CTPA?
- Outcome Prediction for PE patients



# WHO SHOULD GET CTPA?



# CLINICAL DECISION RULES FOR PE: WELLS RULE AND GENEVA SCORE

Wells rule	Score	Revised Geneva score	Score
Clinical signs of DVT	3	Age >65 years	1
Previous DVT or PE	1.5	Previous DVT or PE	3
Surgery or immobilization within 4 weeks	1.5	Surgery or fracture within 1 month	2
Active malignancy	1	Active malignancy	2
Alternative diagnosis less likely than PE	3	Unilateral lower limb pain	3
Hemoptysis	1	Hemoptysis	2
Heart rate >100 beats/min	1.5	Heart rate 74–95 beats/min	3
		Heart rate >95 beats/min	5
		Pain on lower limb deep vein palpation and unilateral edema	4
Clinical probability (revised Wells score)		Clinical probability	
Low	<2	Low	0–3
Intermediate	2–6	Intermediate	4–10
High	>6	High	≥11
PE unlikely	≤4		
PE likely	>4		

Wells PS et al. Thromb Haemost 2000; 83:416–420.

Wicki J et al. Arch Intern Med 2001; 161:92–97.



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# CTPA IS NOT NEEDED<sup>1,2</sup> FOR:

“Low” or “unlikely” clinical probability

+

Negative high-sensitivity D-Dimer

1. Anderson DR, et al. JAMA. 2007;298(23):2743-2753.
2. Van Belle A, et al. JAMA. 2006;295(2):172-179.



# D-DIMER CUTOFF: THE ADJUST-PE STUDY<sup>1</sup>

- D-Dimer increases with advanced age, other factors
- **CUTOFF = AGE x 10  $\mu\text{g/L}$** 
  - for patients over 50 years allows exclusion of PE clinically
- More patients (~30% vs 6%) can be excluded without needing imaging using cutoff

# PERFORMANCE OF CTPA IN ACUTE PE

- Meta-analysis<sup>1</sup>: 3000+ patients, end-point: 3 month fatal VTE
- **NPV of CTA 98.8% (same as Pulm Angio)**
- Pooled incidence of VTE at 3 mos: 1.2%
- Negative CTA for PE safely excludes acute PE in all patients; no need to do Doppler US

1. Mos ICM, et al. J Thromb Haemost 2009; 7: 1491-8.



# PROGNOSIS OF ACUTE PE

- Weakly correlated to clot burden
- Strongly correlated to RV dysfunction



# RV DYSFUNCTION<sup>1-3</sup>

- Elevated RV pressure → IV septal shift → diastolic dysfxn + decreased LV filling → systolic LV failure → cardiogenic shock
- RV afterload, wall stress increases →  
Elevated troponins, BNP
- **RV dysfunction is predictor of short-term mortality**

1. Mos ICM, et al. J Thromb Haemost 2009; 7: 1491-8.

2. Goldhaber SZ et al.. Lancet 1999; 353:1386–1389.

3. Ribeiro A, Lindmarker P, Juhlin-Dannfelt A, Johnsson H, et al. Am Heart J 1997; 134:479–487.

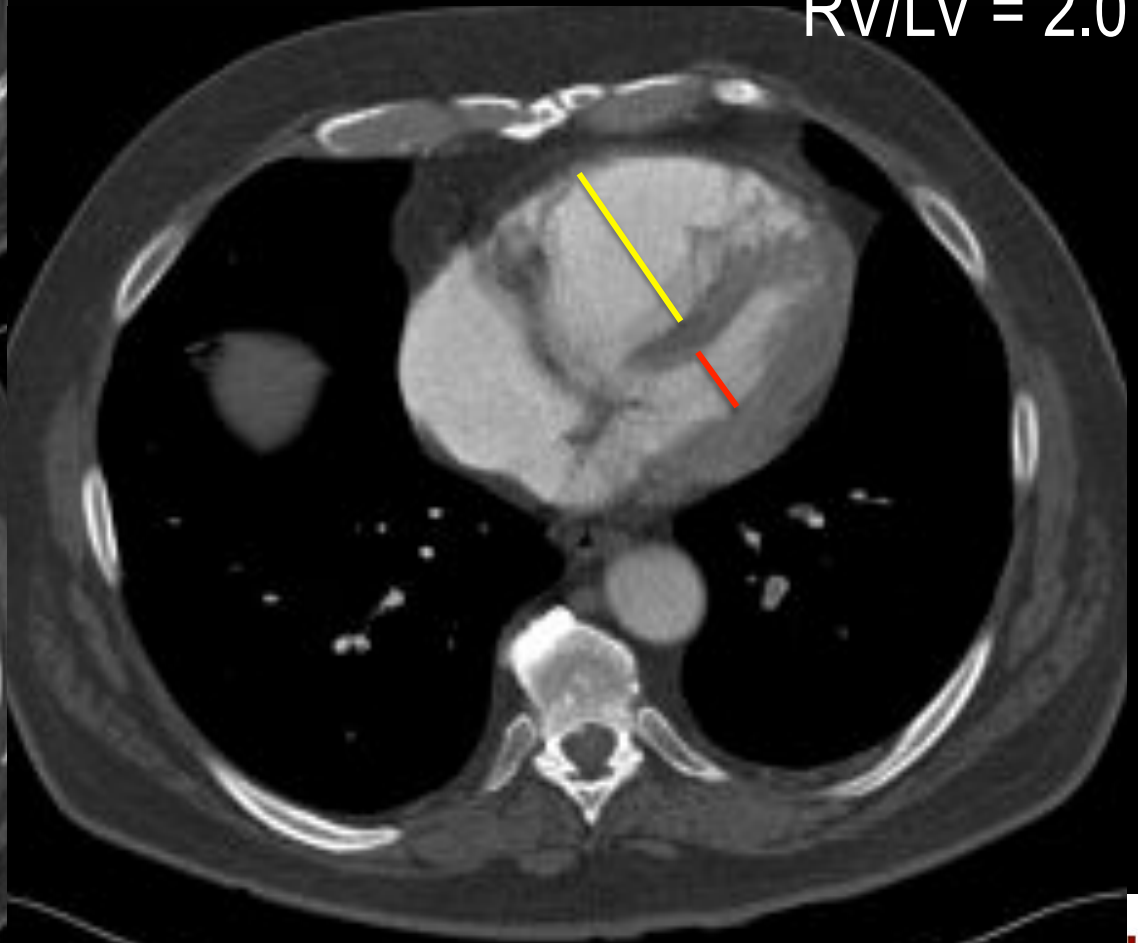
# RV DYSFUNCTION BY CTPA



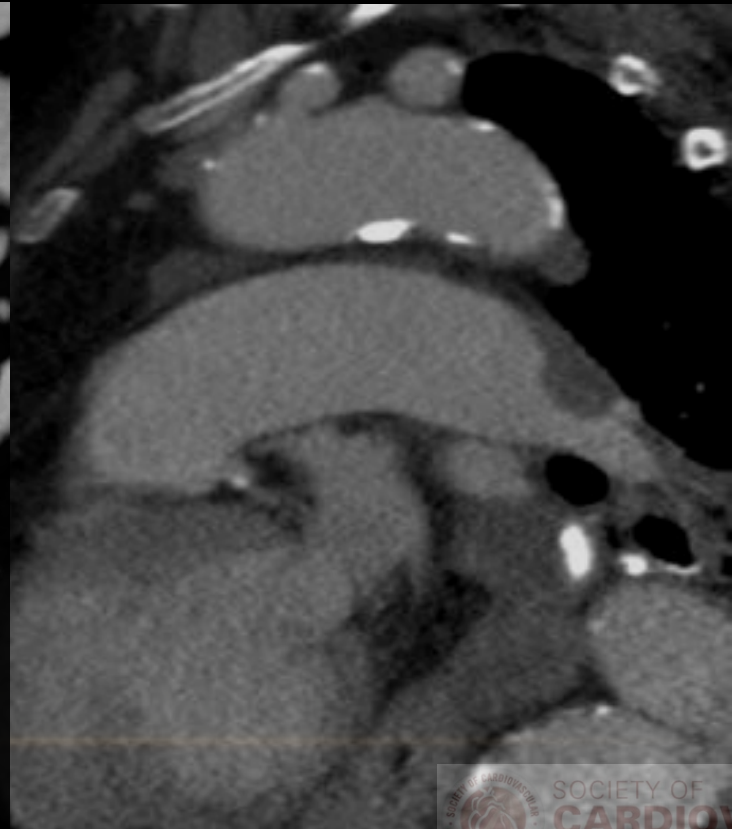
- **RV/LV ratio:**
- Measure on axial or 4CH views, at level of mid-valve
  - < 1.0 excludes adverse outcomes -
    - ? home therapy
  - >1.0 correlates to worse outcomes

# RV / LV RATIO

RV/LV = 2.0



# CHRONIC PULMONARY VASCULAR DISEASE: CTEPH



# CHRONIC THROMBOEMBOLIC PULMONARY HYPERTENSION (CTEPH)

- PAP > 25 mmHg persistent at 6mos after PE
- Pulm Vasc Resistance > 3 Wood units
- Chronic PA obstruction despite > 3 mos uninterrupted, effective anticoagulation
- Pathogenesis poorly understood
  - 80% have hx VTE

# CTA IN CTEPH

- CT more **sensitive** (86%) than angio (70%), MRI (45%).
- CT more **specific** than nuclear imaging
- CT **directly** visualizes wall and mural clot, RV function, pulmonary parenchymal abnormalities
- Better outcomes if “Central” CTEPH (thombectomy)



# CT FINDINGS IN CTEPH

## PRIMARY

- Intraluminal filling defects (webs, strands)
- Stenoses, post-sten. dilatation
- Dilated central PAs, RV
- RVH
- Peripheral PAs small

## SECONDARY

- Mosaic perfusion opacities
- Enlarged bronchial / non-bronchial collaterals



# CT FINDINGS IN CTEPH

## PRIMARY

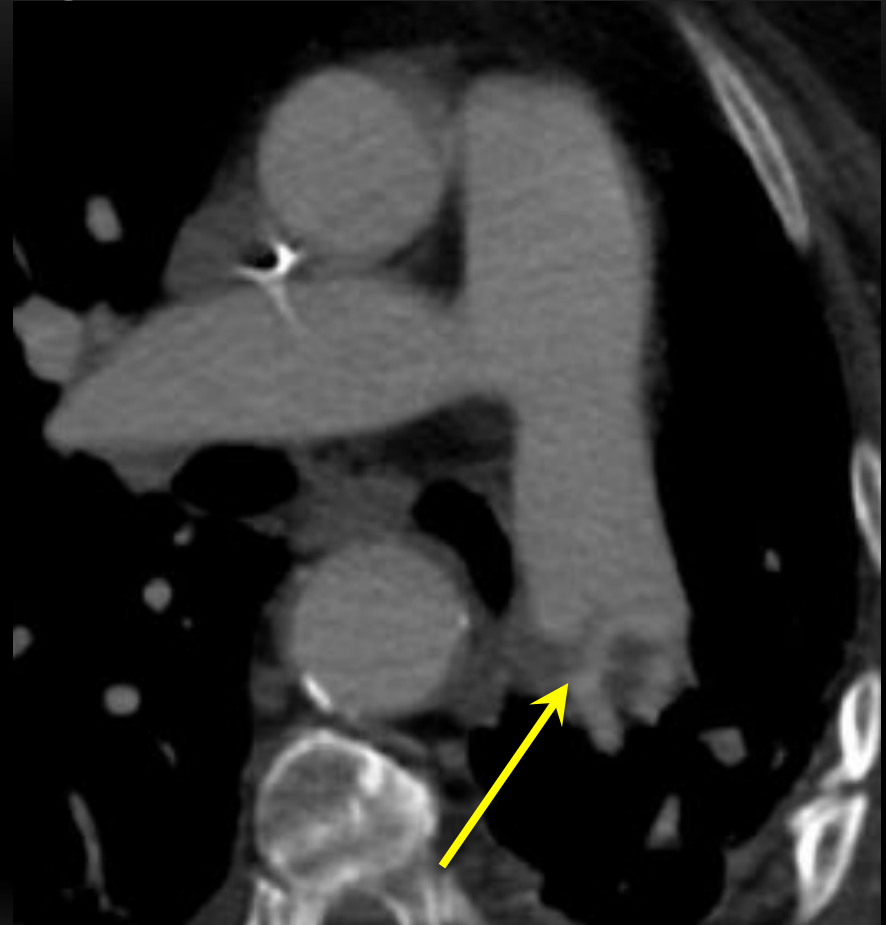
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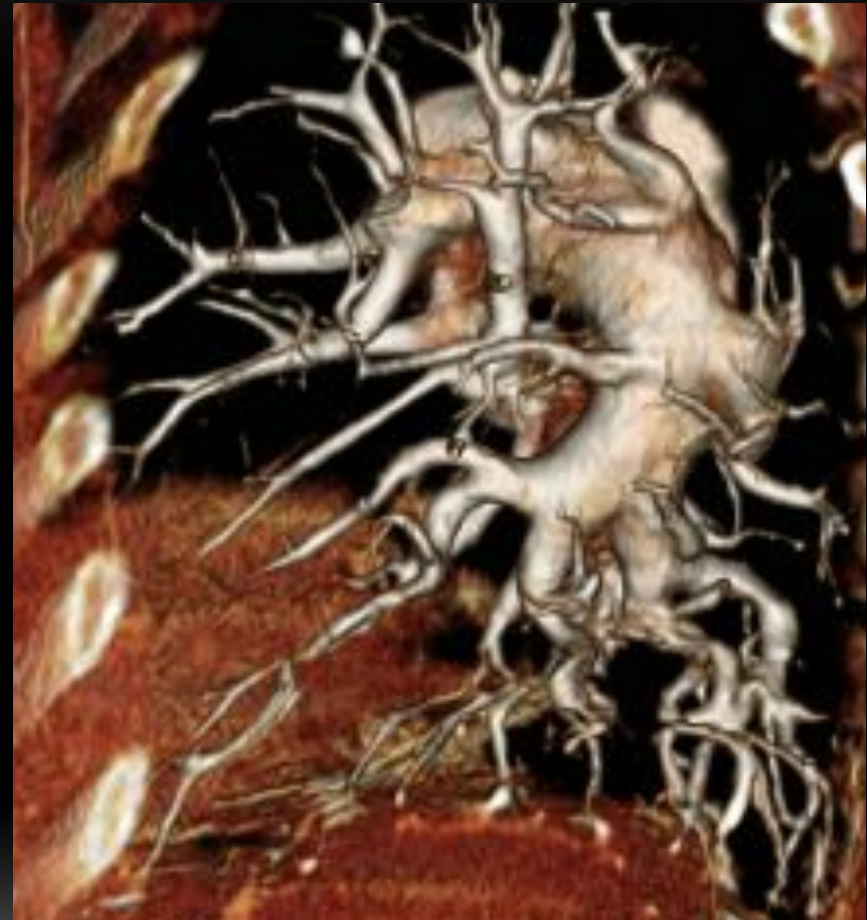
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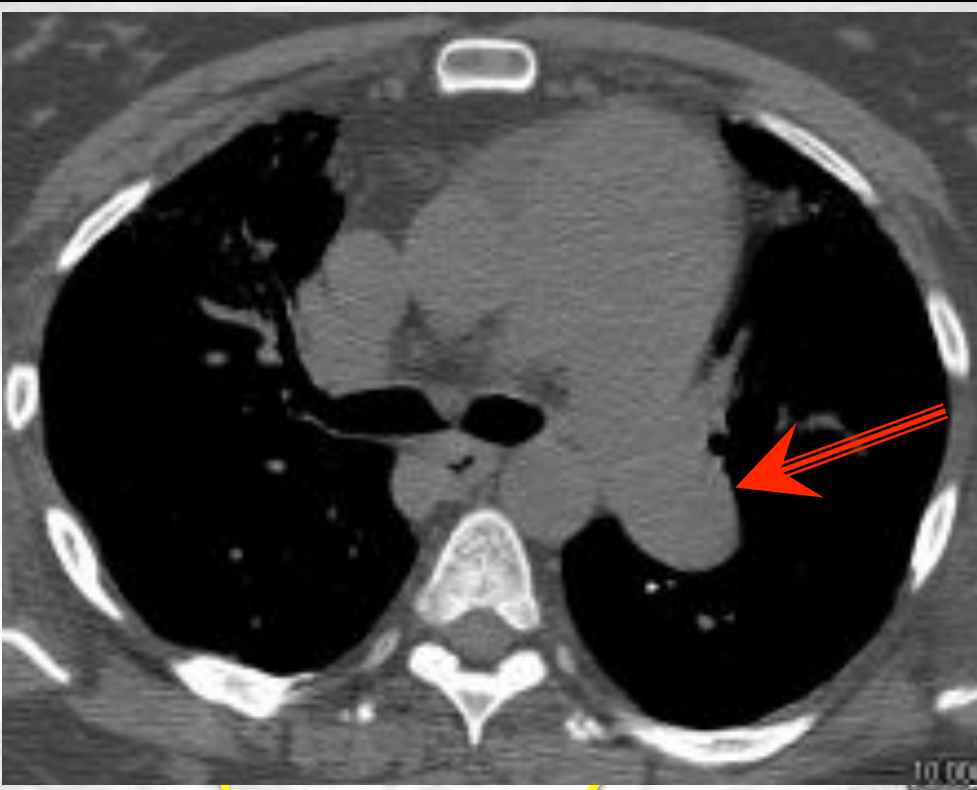
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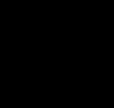
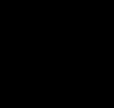
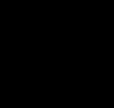


## SECONDARY

- Mosaic perfusion opacities
- Enlarged bronchial / non-bronchial collaterals



# AORTIC DISEASE

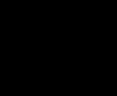
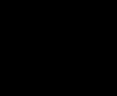
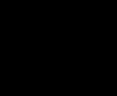


# AORTIC DISEASES

- Aneurysms
- Vasculitis
- Trauma
- Acute Aortic Syndromes
  - Penetrating Atherosclerotic Ulcer (PAU)
  - Intramural hematoma (IMH)
  - Aortic Dissection



# ACUTE AORTIC SYNDROMES



# ACUTE AORTIC SYNDROMES

Acute, life-threatening abnormalities of aorta

SX= intense chest or back pain

Spectrum:

Penetrating Atherosclerotic Ulcer (PAU)

Intramural Hematoma (IMH)

Aortic dissection - 75%



# ACUTE AORTIC SYNDROMES

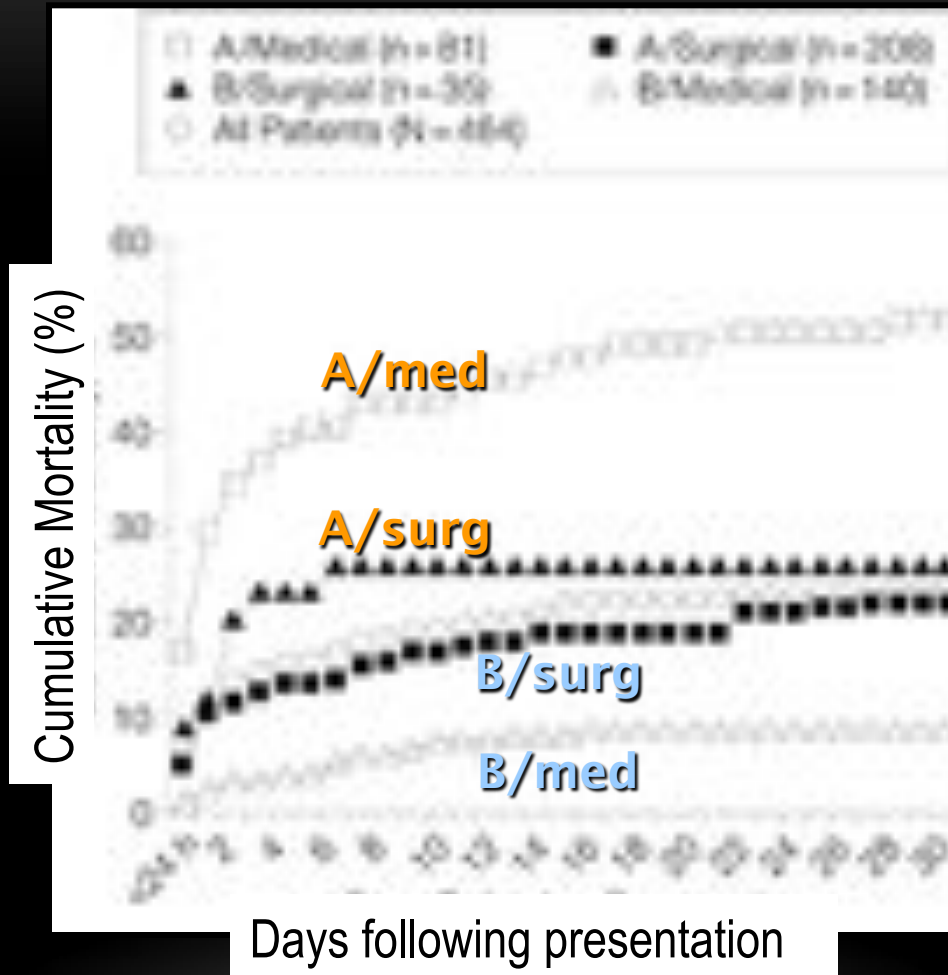
RARE: 2.6-3.5 /100k/yr in US

MI is 50 - 100X more common

But....LIFE THREATENING

Diagnosis and management is imaging based!

# NATURAL HISTORY OF DSX



# ROLE OF CT IN IMAGING ACUTE AORTIC SYNDROMES

- Lesion characterization (DSX, IMH, PAU)
- Anatomic Extent of Disease
  - Involvement of ascending aorta
    - (type A vs B)
- location of Primary Intimal Tear (or ulcer if PAU)
- side branch involvement (ischemic complications)
- signs of complications / leak / rupture



# ACUTE AORTIC SYNDROMES



Thoracic and  
Cardiovascular  
Surgery

## Acute Aortic Syndromes: New Insights from Electrocardiographically Gated Computed Tomography

Dominik Fleischmann, MD,\* R. Scott Mitchell, MD,<sup>†</sup> and D. Craig Miller, MD<sup>†</sup>

The development of retrospective electrocardiographic (ECG)-gating has proved to be a diagnostic and therapeutic boon for computed tomography (CT) imaging of patients with acute thoracic aortic diseases, such as aortic dissection/intramural hematoma (AD/IMH), penetrating atherosclerotic ulcer (APU), and ruptured/leaking aneurysm. The notorious pulsation motion artifacts in the ascending aorta confounding regular CT scanning can be eliminated, and involvement of the sinuses of Valsalva, the valve cusps, the aortic annulus, and the coronary arteries in aortic dissection can be clearly depicted or excluded. Motion-free images also allow reliable identification of the site of the primary intimal tear, the location, and extent of the intimomedial flap, and branch artery involvement. ECG-gated CTA also allows the detection of more subtle lesions and variants of aortic dissection, which may ultimately expand our understanding of these complex, life-threatening disorders.

Semin Thorac Cardiovasc Surg 20:340-347 © 2008 Elsevier Inc. All rights reserved.

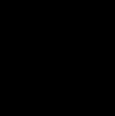
**KEYWORDS** ECG-gated CT, acute aortic syndrome, aortic dissection, intramural hematoma, atherosclerotic penetrating ulcer

# ACUTE AORTIC SYNDROMES

Penetrating Atherosclerotic Ulcer(PAU)

Intramural Hematoma (IMH)

Aortic Dissection (DSX)



# ULCER PATHOLOGY

- **Atherosclerotic ulcer :**
  - aka “ulcerated plaque” (confined to intima)
  - may cause cholesterol embolism
- **Penetrating atherosclerotic ulcer (PAU)**
  - penetrates through internal elastic lamina into media, +/- IMH formation

Adventita

**Media**

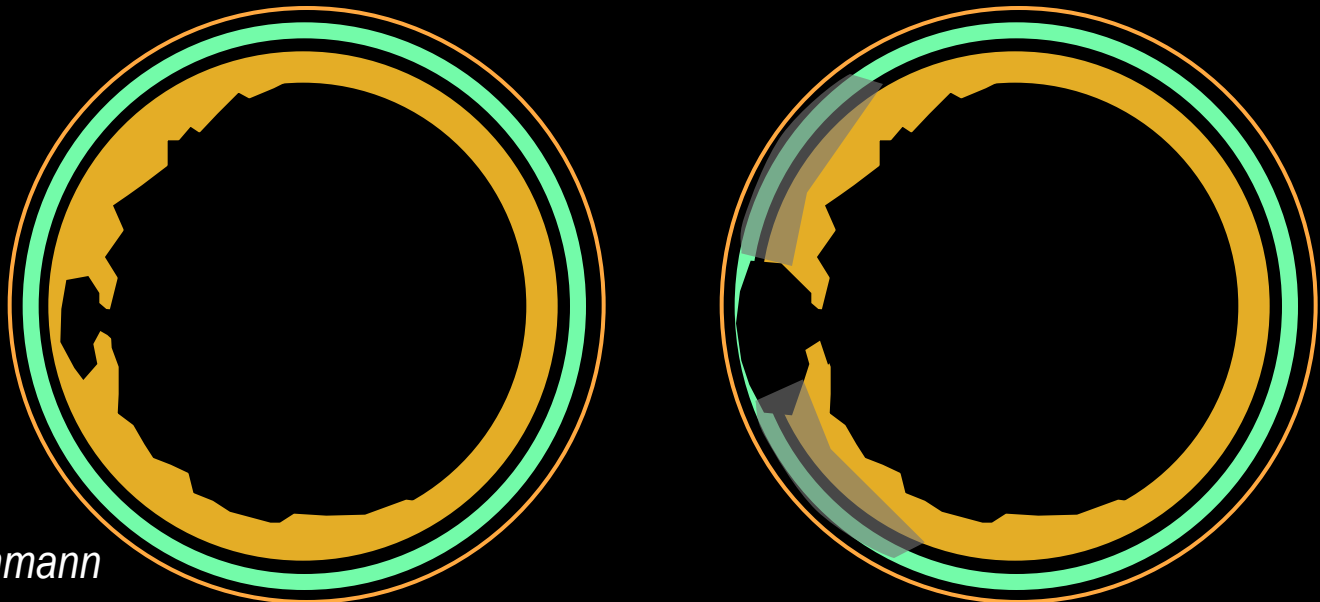
Intima



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Adventita  
**Media**  
Intima



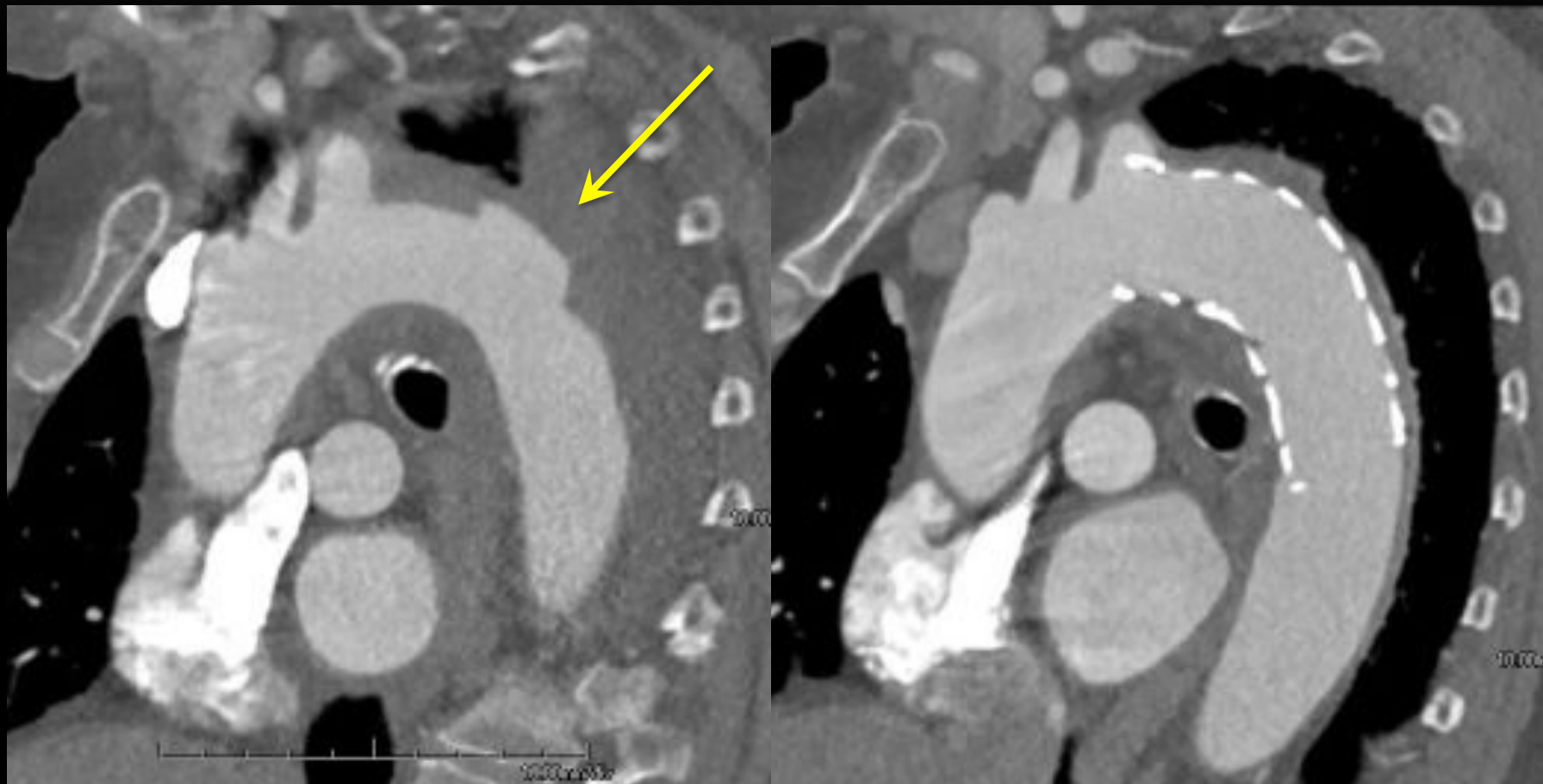


LOGY

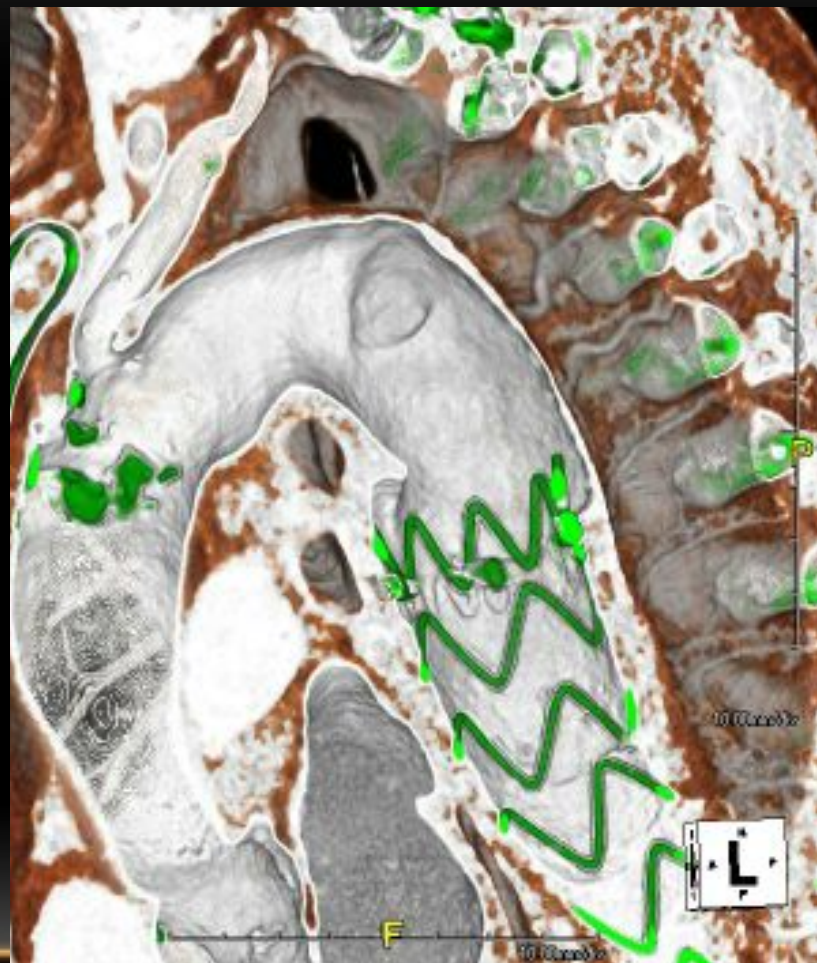
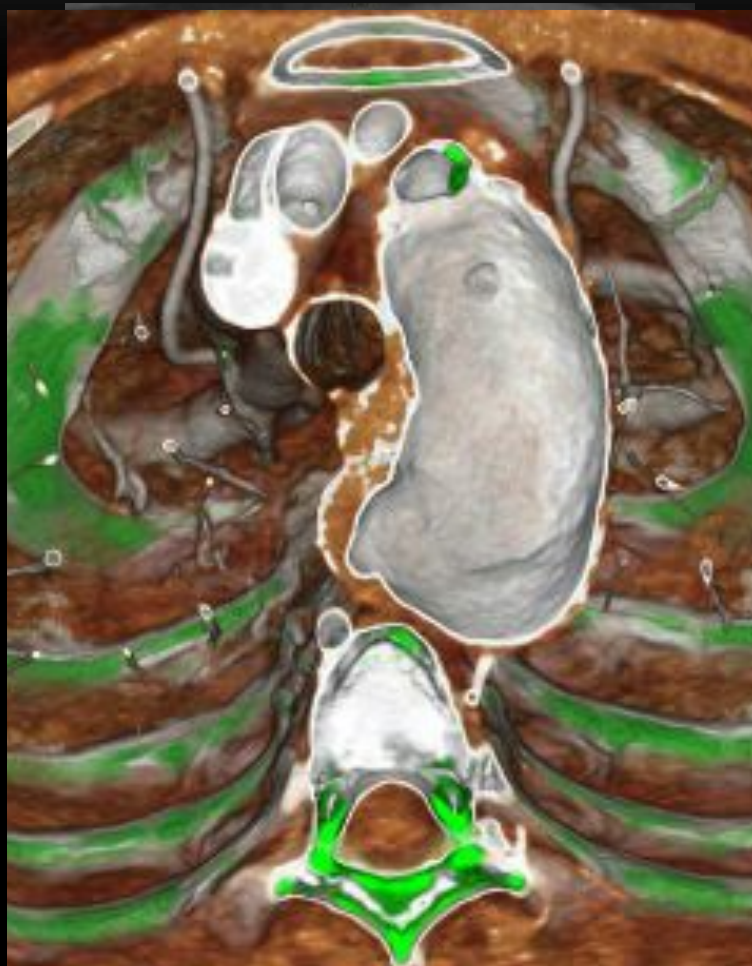
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# PAU: THERAPY



# PAU PROXIMAL TO TEVAR

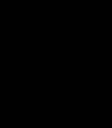


# ACUTE AORTIC SYNDROMES

Penetrating Atherosclerotic Ulcer (PAU)

Intramural Hematoma (IMH)

Aortic Dissection (DSX)

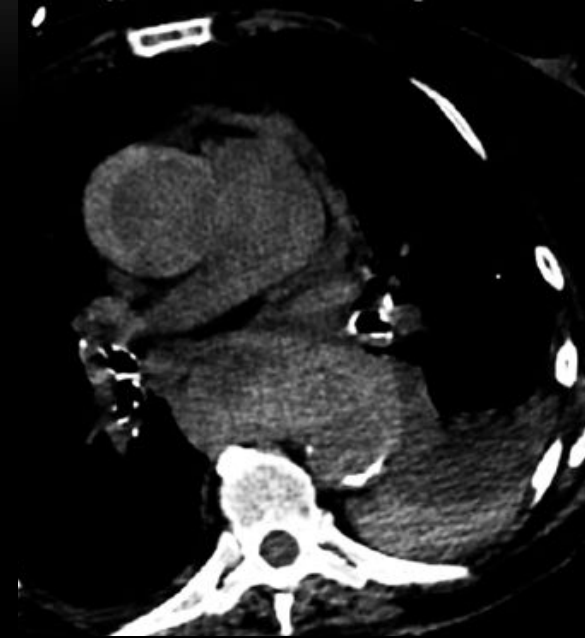


# INTRAMURAL HEMATOMA (IMH)

- IMH is not a disease
- IMH is an imaging finding
  - Seen in DISSECTION and PAU
  - Dynamic

## CT IMAGING GOALS:

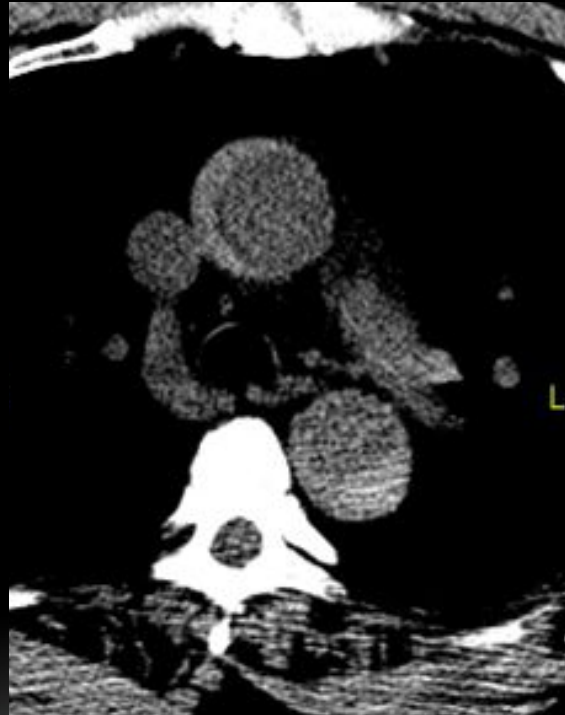
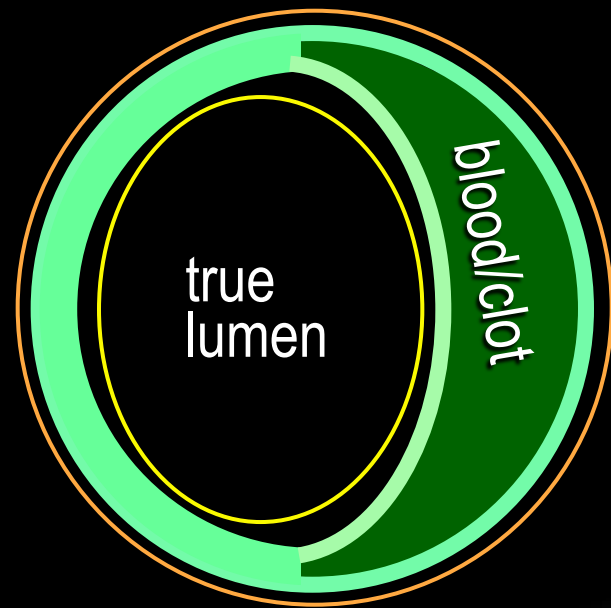
- Type A vs Type B
- presence/absence/location of PAU or intimal tear
- signs of rupture / progression



# Intramural Hematoma

Hematoma located in vessel media

- No communication between true and false lumen



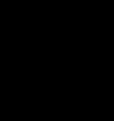
Intramural  
Hematoma

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Intramural Hematoma (IMH)

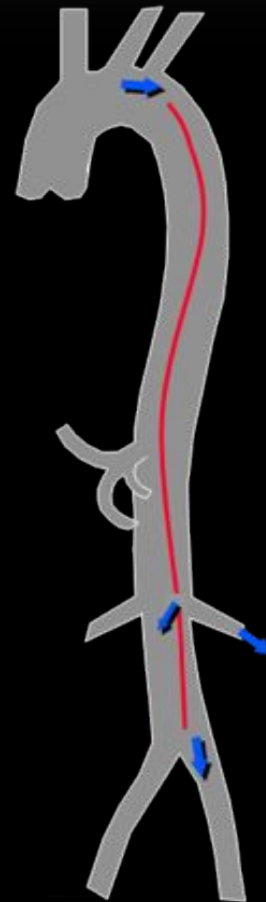
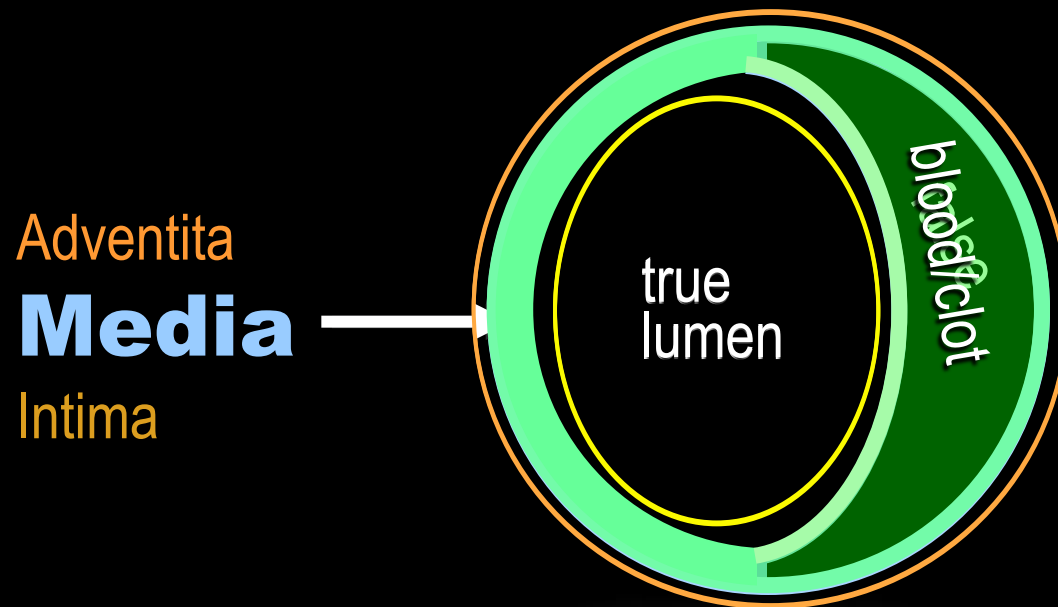
Aortic Dissection (DSX)



# Aortic Dissection

- false lumen within the media

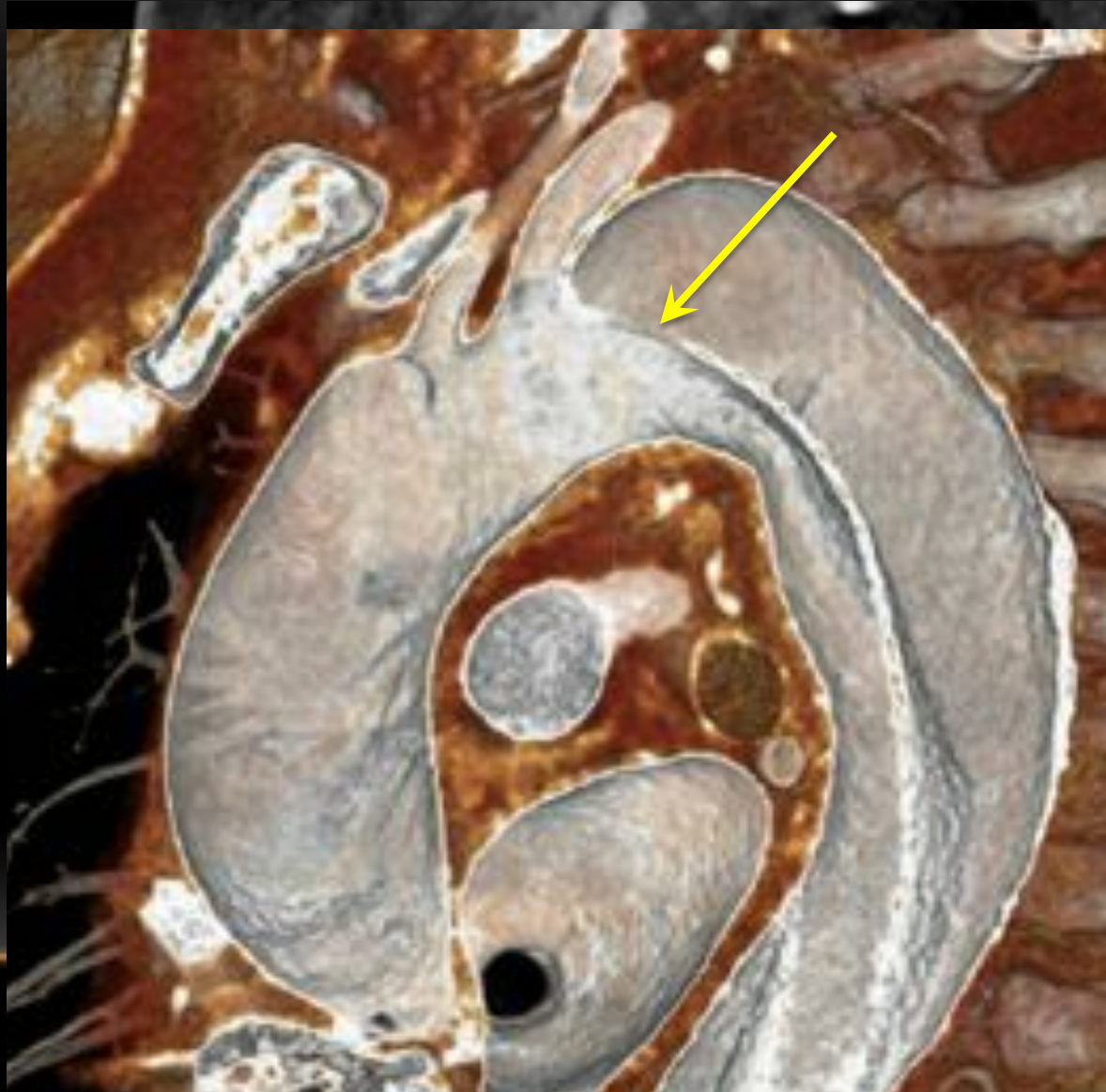
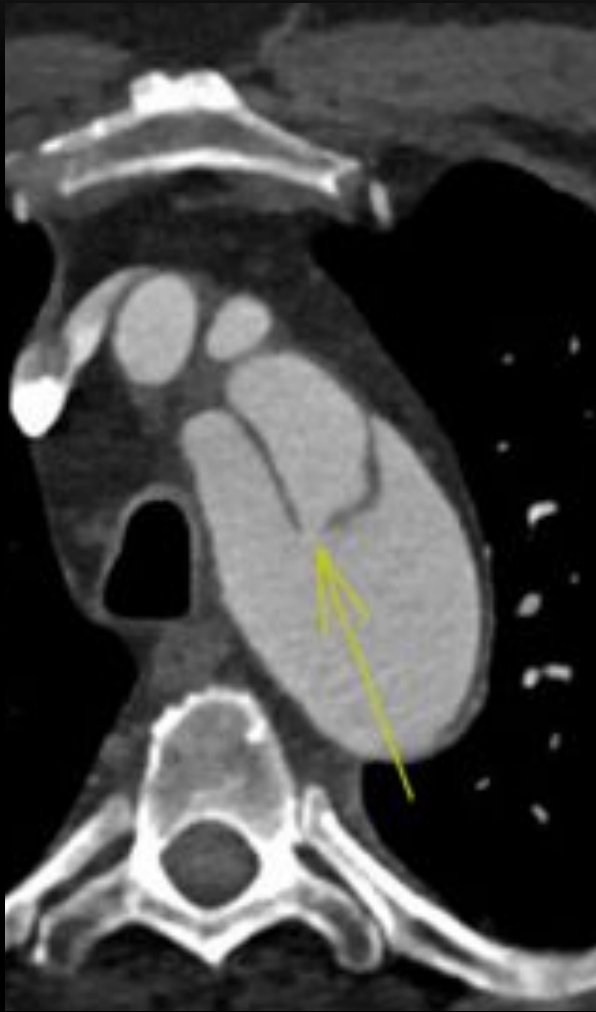
'intimal flap' = inner 2/3 of med + intima →  
**intimo-media flap**



entry tear (primary intimal tear, PIT)

exit tear(s) ['reentry tear', fenestrations]

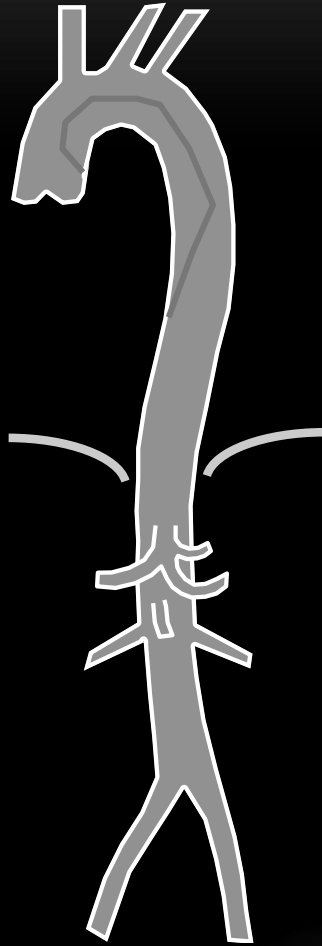
# AORTIC DISSECTION: PRIMARY INTIMAL TEAR (PIT)



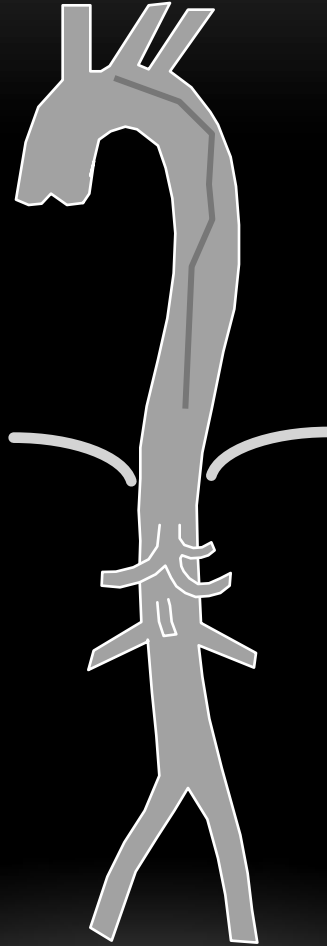
# STANFORD CLASSIFICATION OF DISSECTION

Daily PO et al, Ann Thorac Surg. 1970;10:237-247

Ascending Aorta involved



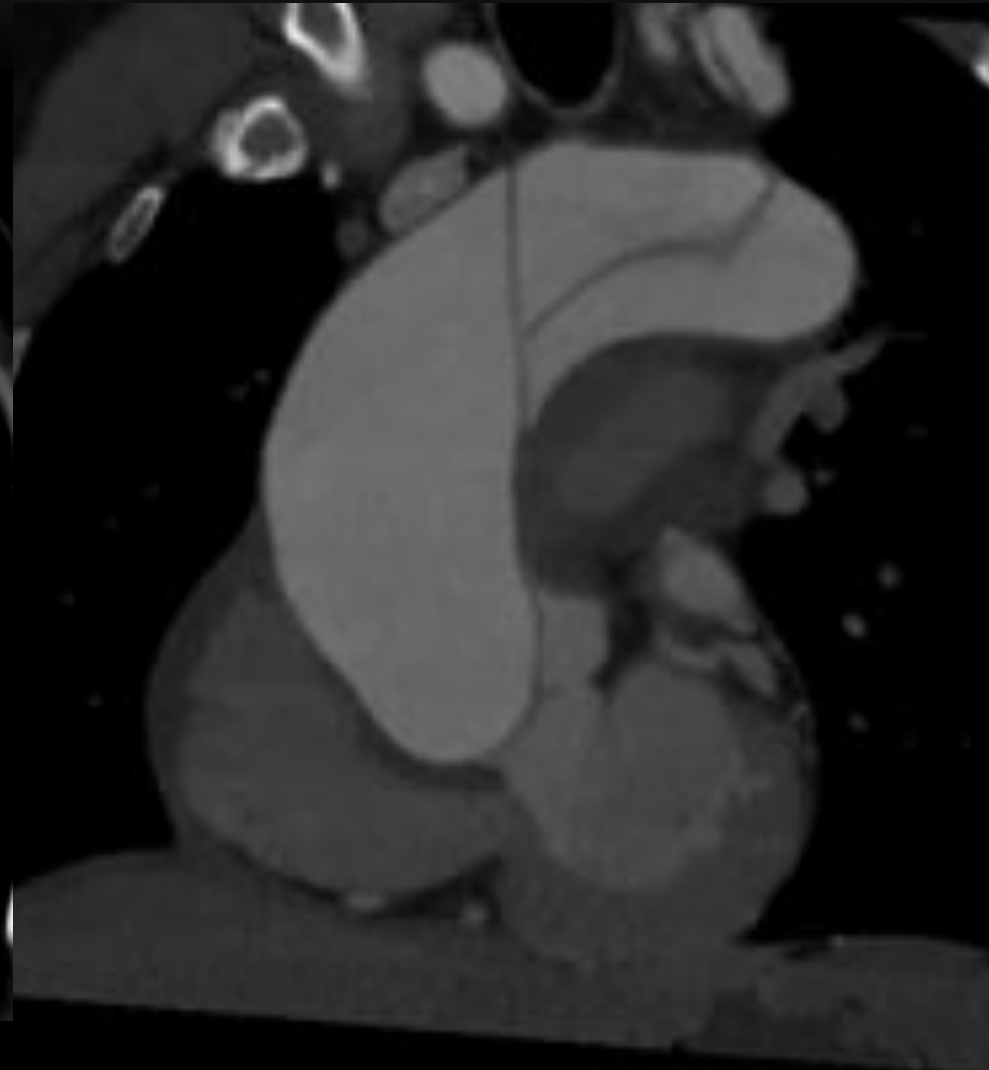
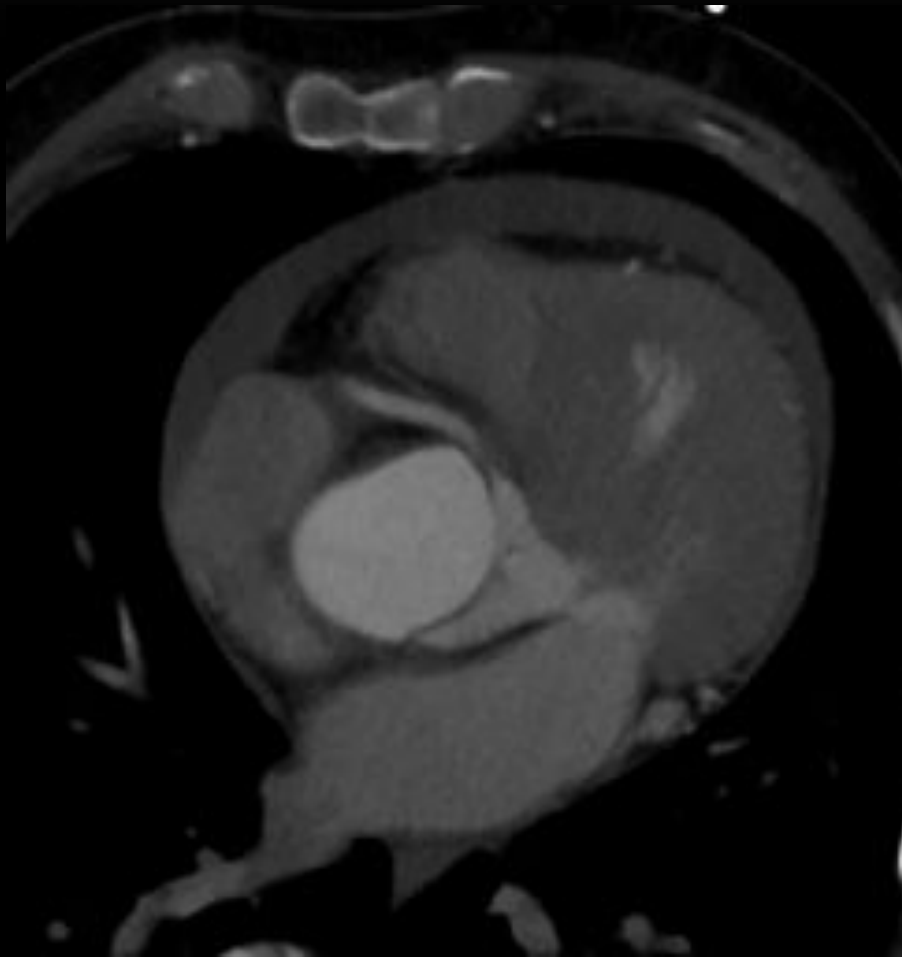
**Type A**



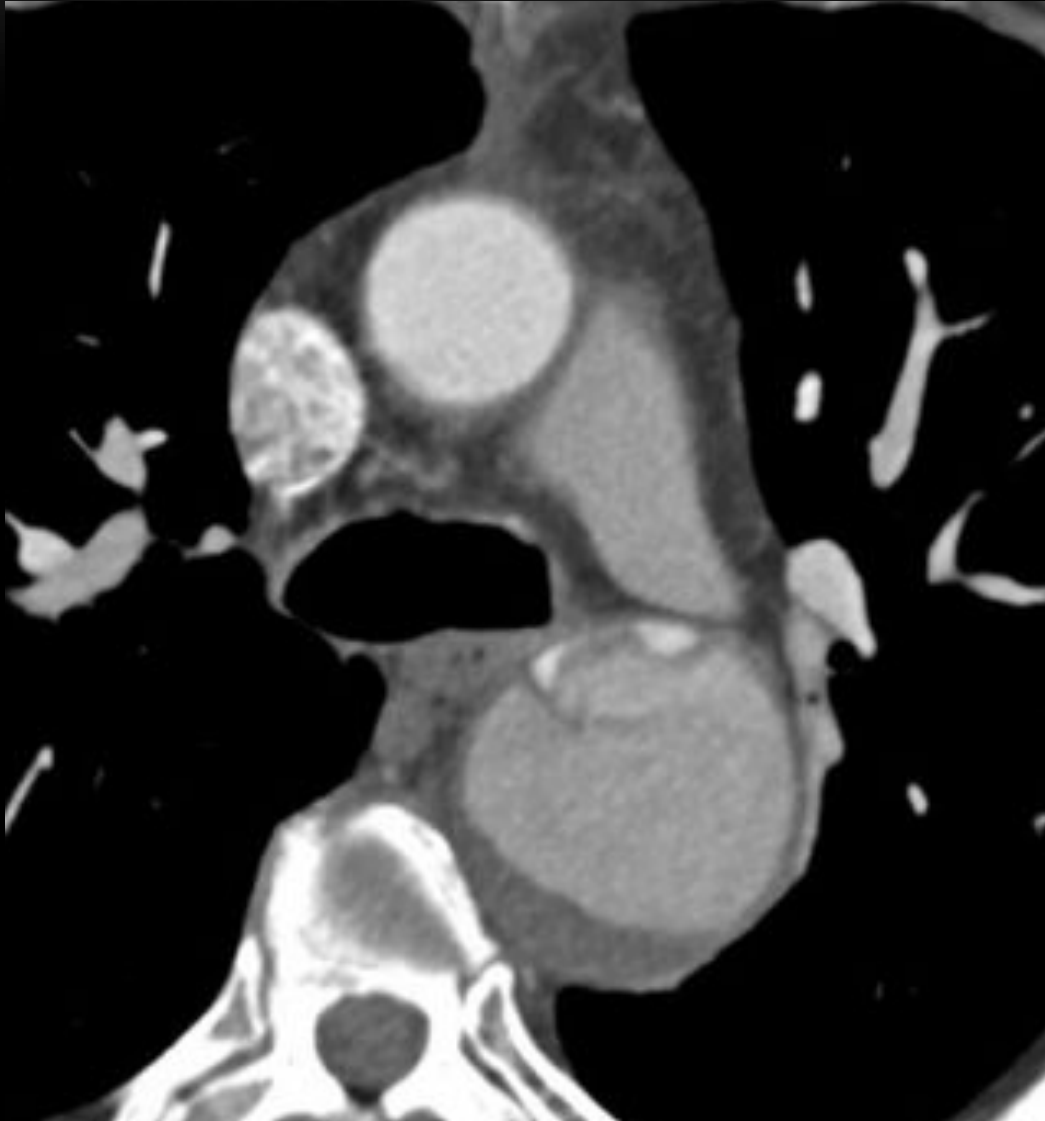
**Type B**

Ascending Aorta **NOT** involved

# AORTIC DISSECTION STANFORD TYPE A



# AORTIC DISSECTION STANFORD TYPE B



# CONCLUSIONS

- Individualized contrast medium and scan acquisition protocols promote consistent, high quality CTA
- CTA adds important diagnostic and prognostic information, and aids clinical management of acute and chronic PE
- Imaging of acute aortic syndromes requires noncontrast imaging and ECG synchronization for optimal disease characterization

# THANKS FOR YOUR ATTENTION!

- *Special thanks to:*

*Dominik Fleischmann, MD*

Handouts:

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